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November 1960

FOOD SUPPLY FOR FALLOUT SHELTERS

Including a Report of the Development of a Special Cereal-based Ration

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FOOD SUPPLY FOR FALLOUT SHELTERS

Including a report of the development

of a special cereal-based ration

Prepared for
Office of Civil and Defense Mobilization
Final report on contract number CDM-SR-60-62

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Abstract

This is a report of a study of the problems of food storage and utilization under conditions which may be expected to prevail in civilian defense shelters of various types, both during occupancy and during the standby period. The report includes discussions of the probable shelter environment and special food requirements, lists of foods available now that could be used if necessary to provision shelters, some estimate of costs, and a discussion of the problems related to food stability. Research and testing of a cereal-based ration specially designed for shelter use are described. Areas for further research are suggested.

The authors wish to thank Mr. W. E. Strope of the Naval Radiological Defense Laboratory for making possible the testing of the cereal-based ration in the shelter habitability tests; Dr. H. Solomon of Stanford University and Miss Marion Sandomire of this Laboratory for advice on surveillance sampling and review of the manuscript; the many staff members who labored so diligently to produce the experimental wheat wafers used in the shelter tests; and the members of the food processing, packaging, and distribution industries who have served as invaluable sources of information.

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Summary

In the event of thermonuclear warfare, survival may depend upon a retreat into shelters for about two weeks. Physical survival may not depend upon food during such a short period. But maintenance of health and spirit will be important preparation for the post-attack era and, to that end, a food supply in shelters is desirable.

Since foods are perishable, shelter stockpiles must be periodically examined during the indeterminate standby period. Partially deteriorated foods must be withdrawn from shelter stockpiles while still acceptable for other purposes, or withdrawn and discarded when they are no longer acceptable. Recurring costs for food stockpile surveillance and periodic food replacement are a fundamental part of the costs of a shelter program.

The temperature and humidity of shelters during the standby period will affect the rate of deterioration of the food stockpile. Humidity levels, if not temperature as well, will be unfavorable to long shelf-life of stored foods. To counteract this effect, special packaging or air-conditioning during the standby period would be needed.

Foods of domestic trade, because of their short shelf-lives, are generally not suitable for long-term storage, nor are they so intended. Consequently, the provisioning of shelters for long-term storage from normal trade sources will be costly, requiring too frequent inspections and replacement of deteriorated items. The development of a new ration specifically tailored for shelter use is recommended as the best solution for provisioning shelters on a nation-wide scale.

Components of such a ration should be palatable to most people, be inexpensive to procure and maintain, have long shelf life, and be convenient to serve under variable but unpredictable emergency circumstances in shelters. A cereal wafer which satisfies most of these criteria has been developed at this Laboratory. The wafer consists mainly of wheat; it can be used as an acceptable food by itself for short periods; and it can be combined in a variety of ways with a few inexpensive flavor adjuncts to lend variety to the diet. Its maximum storage life has not yet been determined.

The cost of a nation-wide food stockpiling program for shelters will be high and any research directed toward reducing that cost should provide immense financial savings and might even mean the difference between success and failure of the program. Of greatest urgency are studies on ration formulation and stability, packaging, shelter environment, and surveillance sampling and quality evaluation methods.

FOOD SUPPLY FOR FALLOUT SHELTERS

Chapter 1. INTRODUCTION

Authorization and General Objectives

This report is prepared in fulfillment of a Memorandum of Understanding between the Office of Civil and Defense Mobilization and the United States Department of Agriculture, Agricultural Research Service. The report is a statement of problems of food selection, food storage during the stand-by period, and ultimate utilization in fallout shelters. It includes discussion of product development and preliminary evaluation of a cereal product specifically suitable for shelter provisioning. Such a product was necessary for use in evaluations of ration and food service concepts of shelter supply. The objectives of this investigation have been to broaden understanding of the interactions of food supply and utilization with the design, management, and function of fallout shelters; and to bring into a clearer focus the areas of research that will lead to a more satisfactory plan for provisioning shelters than any that might be made on the basis of present knowledge.

Basic Precepts

The many problems of food supply and utilization have been considered by the OCDM Interdepartmental ad hoc Advisory Group on Research and Development for Food for Shelters. Their deliberations have led to a series of basic precepts relative to fallout shelter requirements and human needs under emergency conditions of survival during shelter occupancy. These assumptions are, of course, subject to further consideration and reevaluation. They will be listed and discussed very briefly here in order to delineate the framework within which this research has been conducted.

A 14-day shelter occupancy (or pin-down) period is designated as an appropriate one to use in making plans for food stocks in fallout shelters. The rate of radioactive fallout decay is such that shelter occupants would probably be able to leave the shelters, at least for short periods, within two weeks of the attack. If, however, the shelter stay had to be prolonged, two weeks' supply of food could be rationed to last for perhaps double that time, without serious damage to the occupants.

An adequate water supply is imperative. OCDM engineers estimate that one gallon per man day is required—two quarts to be used for food and drinking and two quarts for other purposes. The water source is a part of the shelter design and should be provided as a basic structural component: as piped water from a reliable reservoir, a well, or a stored supply. In the last instance, water might be procured with food supplies, held in food storage space, and maintained during the standby period in the same way as food stocks.

Food is probably not necessary for bare survival of healthy people if the shelter stay is limited to two weeks. Most of the population could live if only an adequate supply of water is available. It is considered essential, though, that occupants of shelters maintain body strength and resistance to disease so that they will be best equipped to cope with a difficult post-attack environment. Also, a fairly palatable food supply should contribute to morale, and control of the food supply might be used as a tool in the management of a shelter population. In the event that the pin-down period is prolonged, food would be essential, of course. The exact pin-down period can not be predicted.

A food supply to provide each occupant with about 2000 calories per day is considered appropriate. Reason for the selection of such a high value is related to the indeterminate nature of the emergency under which the food would be used. If the shelter were overcrowded by 100 percent, only 1000 calories per day would be allowable. If the shelter stay is prolonged or if other sources of food could not be developed within the 14-day period, a stretching-out of this ration would be necessary.

Special diets for infants, invalids, and the aged are considered to be a medical problem. Nevertheless, the shelter food supply should include items usable for such cases. Most useful ration components for such purposes will be dried milk and a cereal product that could be soaked to make a gruel requiring little or no chewing. Enteric feeding formula should be a part of the medical stockpile, and stocked there in quantities suitable for feeding bottle babies who cannot be weaned. In addition, the medical supplies should include appropriate bottles and related equipment for infant feeding.

Costs of food supplies for shelters should be kept to a minimum. National policy at the present time places the responsibility for financing the program of shelter construction, provisioning, and maintenance directly on the individual

or private or local organization. This will result in innumerable small purchases--not the most economical approach to so vast a problem as feeding almost the entire population for two weeks. Therefore, costs of a recommended shelter food program should be kept very low so that the program will be feasible for as large a part of the population as possible.

Information Sources

Shelter investigations conducted to date (12,13,15, 33,34,35,36,37,38,43,45,46,58)[1/] have treated food supply problems in rather narrow circumstances. In some studies, cost was implied as a determining factor and only bare survival rations were considered necessary. One study, oriented to implications of shelter management, accepted as a basic necessity a rather expensive ration concept of two hot one-dish meals per day plus a light breakfast. Some studies went no further than to indicate food was to be served to occupants, or that storage space for provisions should be included in design. Protection and management of provisions during the stand-by period and problems related to the perishability of the foods were not often mentioned, although at least one study indicated that refrigeration of food supplies might be required to obtain a suitably long shelf life.

A broader and more detailed inspection of the food and feeding problems is essential. The objective of the present report is to bring considerations of food problems to bear on ultimate decisions of shelter design and management.

A thorough literature survey of research on food stability was recently conducted for the Office of Civil and Defense Mobilization by Woodroof (61). In addition to the bibliography, Woodroof includes many helpful suggestions on several aspects of shelter provisioning. Much information uncovered is of value in consideration of long-term storage of foods. However, because of the unique problems encountered in provisioning of shelters, very little of the published literature on long-term food storage is strictly applicable.

1/ Numbers in parentheses refer to literature references.

The problems in stocking shelters differ from those encountered in most food-handling situations. Similarity exists with some specialized food programs, such as stockpiling of military combat and survival rations; but, in the last analysis, several basic differences are involved. Long-term storage is a requirement for both, but supplies for shelters must be held in relatively small isolated caches while military supplies can be held in large depots. This makes use of refrigeration feasible for expensive combat rations while it remains of questionable economic status for individual shelters, particularly if low cost foods are selected. Caloric requirements and nutritional balance for military use in combat are more demanding than for a survival ration for short-term shelter existence. Military survival rations are generally designed for severe water limitation and very short duration--5 to 6 days. Relatively high food costs, higher than are necessary to supply the entire civilian population for survival, are justified to keep the troops in a good state of morale and physical condition.

Much of the published information on long-term food storage concerns military rations. Although not strictly applicable to shelter problems in most instances, this information does provide useful reference material for extrapolations and for judging relative stabilities of certain foods.

Industry sources, including processors of food and manufacturers of packaging materials for foods, have been consulted for information on shelter provisioning. In general, technology beyond trade practice is available from these sources even though company operations are generally geared to markets that have a quick turnover of products.

Data on food composition have been taken, mostly, from "Food," the U. S. Department of Agriculture's Yearbook, 1959. Cost figures have been compiled from various sources, including wholesale price lists from various food distributors in the San Francisco Bay area. Weather data and ground temperatures are from Weather Bureau, U. S. Department of Agriculture, and other publications (2,8,28,48,53,57,62).

Much information necessary for development of this study exists unpublished in the reports of other agencies, institutions, and companies and in the minds of individuals who are concerned with problems related to those of shelter food supply. To bring as much as possible of this information to bear on this project, contacts have

been made and continued with such groups as the National Academy of Sciences--National Research Council Disaster Research Group and Advisory Committee on Civil Defense, New York State Bureau of Nutrition, Naval Radiological Defense Laboratory, Stanford Research Institute, Stanford University, and various agencies in the U. S. Department of Agriculture.

Scope Of This Report

Two major procedures exist as possibilities for provisioning fallout shelters. One procedure would be to rotate food supplies through temporary storage in shelter areas, then channel them into normal food use. In the other system, food stocks would be held until they are no longer acceptable for normal food use, then they would be discarded and replaced by fresh stocks.

For rotated stocks, storage intervals would be short enough to forestall any important change of nutrients, appearance, or palatability. The choice of food would depend upon its routine use rather than upon any attempt to provide an ideal shelter ration. The cost of such provisioning would be limited to handling charges for movement into and out of the shelter and to interest on investment in a larger than customary food inventory.

The system in which foods are held until no longer usuable involves procurement of provisions, surveillance of the stockpile for deterioration, and ultimate replacement of deteriorated products.

Rigorous cost analyses to compare these two procedures have not been made, nor is it likely that they can be, even in general terms. The choice of systems must be made on an individual shelter basis with much attention given to possibilities for ultimate use of food if the rotation system is used.

It is anticipated that most individual family-type shelters, many shelters in buildings that house restaurants, and shelters in organized institutions and military posts will fall into the category for rotated provisions. On the other hand, there will certainly be shelters where it will not be economical or feasible to rotate food supplies into normal use. Increased investment and labor costs for a rotation program could outweigh the replacement costs of some foods if such foods were inexpensive and could be stored long enough.

The study reported herein is limited to food stockpiling for long-term storage and replacement, rather than rotation after short storage periods. Civil defense activities in other agencies have been and are being directed to the problems of shelter provisioning where foods can be rotated (51).

Specific examples of food stockpiles which could be used for many shelters, and general instructions for the management and use of these stores are given in this report. Many shelter situations will exist where modifications in the food lists will be desirable or necessary. It is not possible to foresee every condition that might exist in shelters throughout the country. In any event, it would not be feasible to develop plans for each set of conditions. Decisions on food programs for shelters must be made by those whose responsibility it is to provision shelters; important factors for them to consider are contained in this report which can serve to instruct and guide them.

Chapter 2. THE SHELTER

Structure and Function

The Research Division staff of the Office of Civil and Defense Mobilization and advisory committees and consultants drawn from other Government and private agencies have brought expert thought to bear on the design and function of fallout shelters (12,13,15,33,35,36,37,38,43,45,46). These studies contemplate several types of structures as shelter possibilities.

The basic function of a shelter is to shield its occupants from fallout radiation and, perhaps, from the effects of blast, fire, or biological or chemical agents. Protection from radiation is obtained by shielding; the amount of protection generally depends upon the thickness and density of the material used. Most shelter plans call for shielding of at least 3 feet of earth or 18 inches of concrete.

Shelters could be specially built structures constructed underground or above ground if properly shielded. Some existing structures are suitable for use as shelters and some can be modified to serve the purpose. Underground garages, subways, service tunnels, mines, etc. are likely possibilities. Basements or inside rooms of some homes and industrial, commercial, and public buildings would be usable, but might need some additional shielding or facilities.

Various studies recommend 8 to 12 square feet of space for each person. Bunks are in tiers, and there may be one bunk for each occupant at rated capacity of the shelter (cold bunk system) or one bunk for two occupants (hot bunk system). With the latter arrangement, feeding, as well as sleeping, would be done in shifts.

In various reports on shelter design, space allotted for preparing and dispensing food varies with the authors' concepts of the appropriate shelter fare. Most reports agree that any extensive amount of cooking is not practical because an adequate fuel supply would be too costly and, of even greater importance, the heat and moisture load to be removed from the shelter would be excessive. Preliminary studies made at this laboratory suggest that cooking might be feasible in some shelters. This is discussed in Chapter 5.

Electrical power for lighting, running the ventilation system, and perhaps for moderate use in heating food or beverages is considered essential for larger shelters. The electrical power would come from regular sources if power plants or the transmission grid had not been knocked out. If normal supplies were not available, power could be produced by generating units within the shelter.

An important aspect of the shelter design is the space for food storage. Food must be stored for each person for fourteen days' occupancy. The space required depends on the ration and the packaging used. Where existing buildings are used or modified for use as shelters, food storage space must be made available. Locked rooms or locked master containers must be provided to secure the food stockpile in buildings that are used for other purposes.

Various feeding plans, storage space required for different rations, arrangement of food in storage, space and equipment required for food preparation, and estimates of heat produced by cooking will be discussed in subsequent chapters as food plans are developed.

Shelter Conditions During the Standby Period

When shelters are constructed they must be provided with all items needed for use under the most extreme emergency conditions. There will be no time to gather stocks after the warning sounds. Supplies must be managed during the standby period so as to be functional for an indefinite time. For planning purposes, five to ten years is considered minimal, and much longer periods could be anticipated.

The shelf life of foods stored in shelters and the packaging required to protect these foods will be greatly influenced by conditions existing in the shelters during the standby period. Generators, motors, fans, bunks, bedding, and medical and sanitation supplies also may be drastically affected.

Shelters can be categorized according to these conditions prior to occupancy: heated or unheated, ventilated or not ventilated, dehumidified, or even completely air-conditioned. Specific information on temperature and humidity conditions in various types of shelters prior to occupancy seems to be practically non-existent in this country. Approximate conditions can be derived by extrapolation from other data. Such data are not adequate for

the most efficient decision-making in regard to food selection and packaging requirements, but they offer a first approximation. Actual observations made in various types of shelters in different areas of the country are needed.

Environmental conditions that have the most effect on the storage life of foods and their containers are temperature and humidity. The rate of degradation is influenced by temperature (see discussion in Chapter 3). Storage life of many materials will also be shortened if high humidities occur. Moisture condensation on surfaces will cause corrosion or rusting. At high humidity, the moisture content of organic materials, such as fabrics, leather, and paper products, will rise and, at a critical humidity for each material, rotting and mildewing will occur.

Other factors which affect food storage plans include atmospheric pollutants, insect and rodent damage, pilferage, vandalism, and mechanical hazards. All factors can vary widely, depending on the structure of the fallout shelter, its location, and the management practices during the standby period.

Temperatures inside underground shelters, prior to occupancy, will be determined largely by the surrounding ground temperature, if no temperature control is exercised. Ventilation, either natural or mechanical, will be so small in most cases that it will have little effect. The average annual ground temperature at the depth where shelters will normally be built is commonly about 1 to 2 degrees higher than the average annual air temperature. In areas with prolonged snow cover and in desert country the differences are somewhat greater. Coastal areas with relatively warm ocean winds may have average soil temperatures slightly below the average air temperature.

Ground water from strata 30 to 60 feet deep usually has a temperature approximating that of the average annual ground temperature. The temperature of the water does not vary more than 1 or 2 degrees during the year and can be used to estimate the average ground temperature for a specific locality.

Average annual air temperatures in the United States (excluding Hawaii and Alaska) range from 35° to 75°F. (Figure 1). Most of the population lives in areas having average temperatures between 45° and 65°. Storage life of food is greatly different for the two extreme temperatures and appreciably different between 45° and 65° (see Chapter 3).

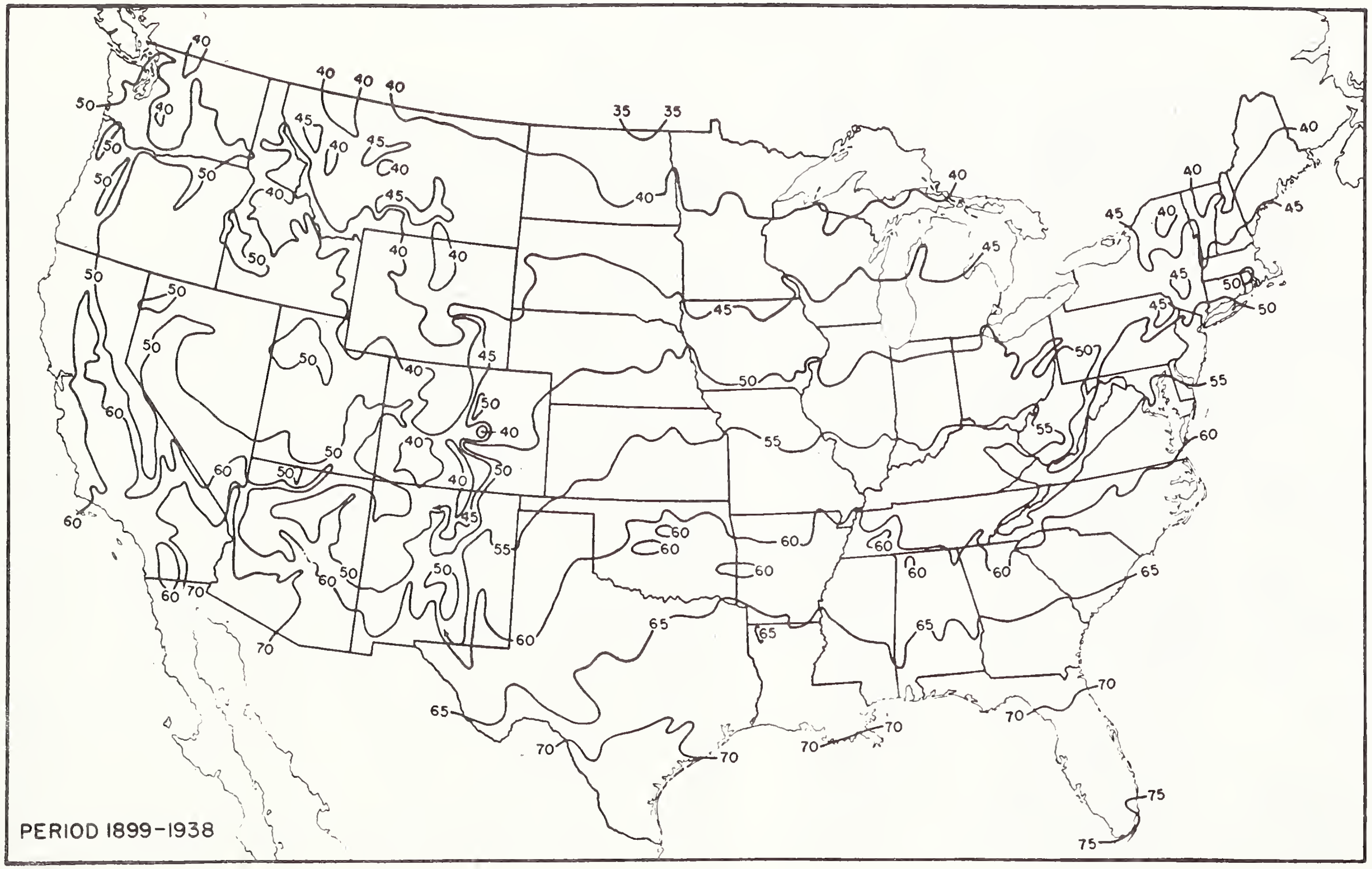

FIGURE 1. Average Annual Air Temperature in the United States
Source: Climate and Man, U.S. Department of Agriculture Yearbook, 1941

Air temperature fluctuates daily and seasonally, but daily fluctuations do not change ground temperature to a significant depty. Seasonal fluctuations do affect ground temperature to an appreciable depth and may have direct bearing on conditions in the shelters. Figure 2 shows some idealized curves for air temperature and ground temperatures throughout the year at various soil depths for a location in an area like St. Paul, Minnesota. The amplitude and period of such cycles are markedly altered by soil type, water content of soil, and surface conditions. In the model shown in Figure 2, minimum and maximum monthly average air temperatures occur in January and July and differ from the average by 30 degrees. Ground temperature fluctuates less as depth increases. Maximum deviation from the average temperature is 21 degrees at the 3-foot depth, 13 degrees at 6 feet, 8 degrees at 10 feet, and 4 degrees at 15 feet. These extremes are not reached simultaneouly but lag as the depth increases; the lag amounts to 24 days at 3 feet, 47 days at 6 feet, 79 days at 10 feet, and 118 days at 15 feet. The lag has an appreciable effect on humidity problems.

The depth of the shelter in the ground will have a bearing on the temperature in the shelter. One proposed design (46) for a 100-man shelter has an arched roof with a maximum height from floor to ceiling of approximately 12 feet. The recommended minimum soil covering for radiation protection is 3 feet. If this shelter were built at such depth that the soil surface were level, the floor of;the shelter would be 15 feet underground. The ceiling would be 3 feet underground at the center and at increasing depth toward the walls. In a situation similar to that described in Figure 2, the minimum temperatures at the 3-foot and 6-foot depts would be below freezing. It may be desirable in cold areas to have more soil over the shelter for greater insulation. The depth of surface soil required would depend upon the amount of ground heat radiating from the floor and walls of the shelter.

Figure 3 is a map of the United States showing depth of soil freezing.

In some areas at some seasons of the year there is a wide variation in the soil temperatures at different depths. In late winter the temperature at the 15-foot level may exceed that at the 3-foot level by 20 degrees; in late summer the situation is reversed and the upper soil is warmer by an equal amount. These temperature

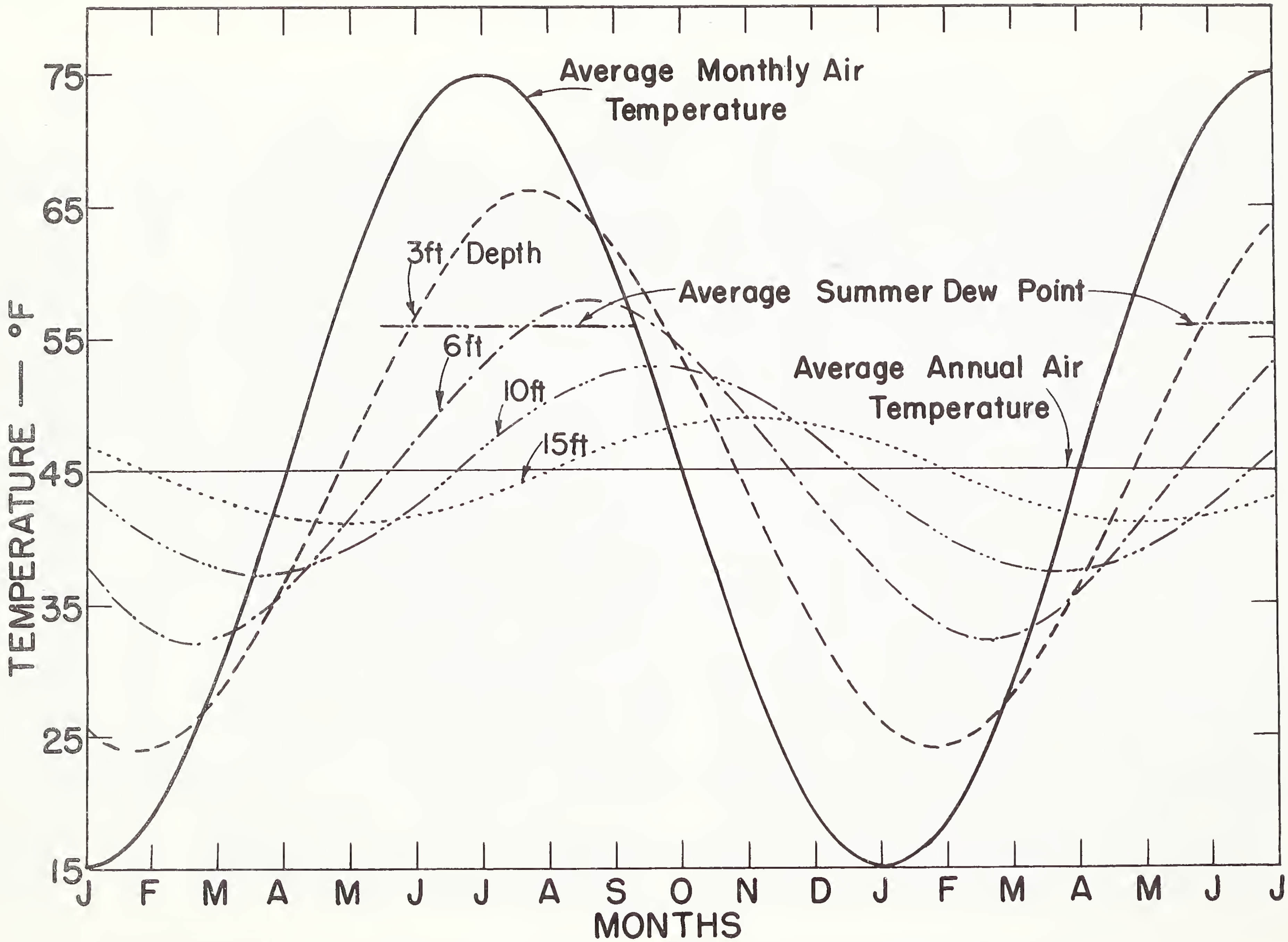

FIGURE 2. Air and Soil Temperatures at St. Paul, Minnesota

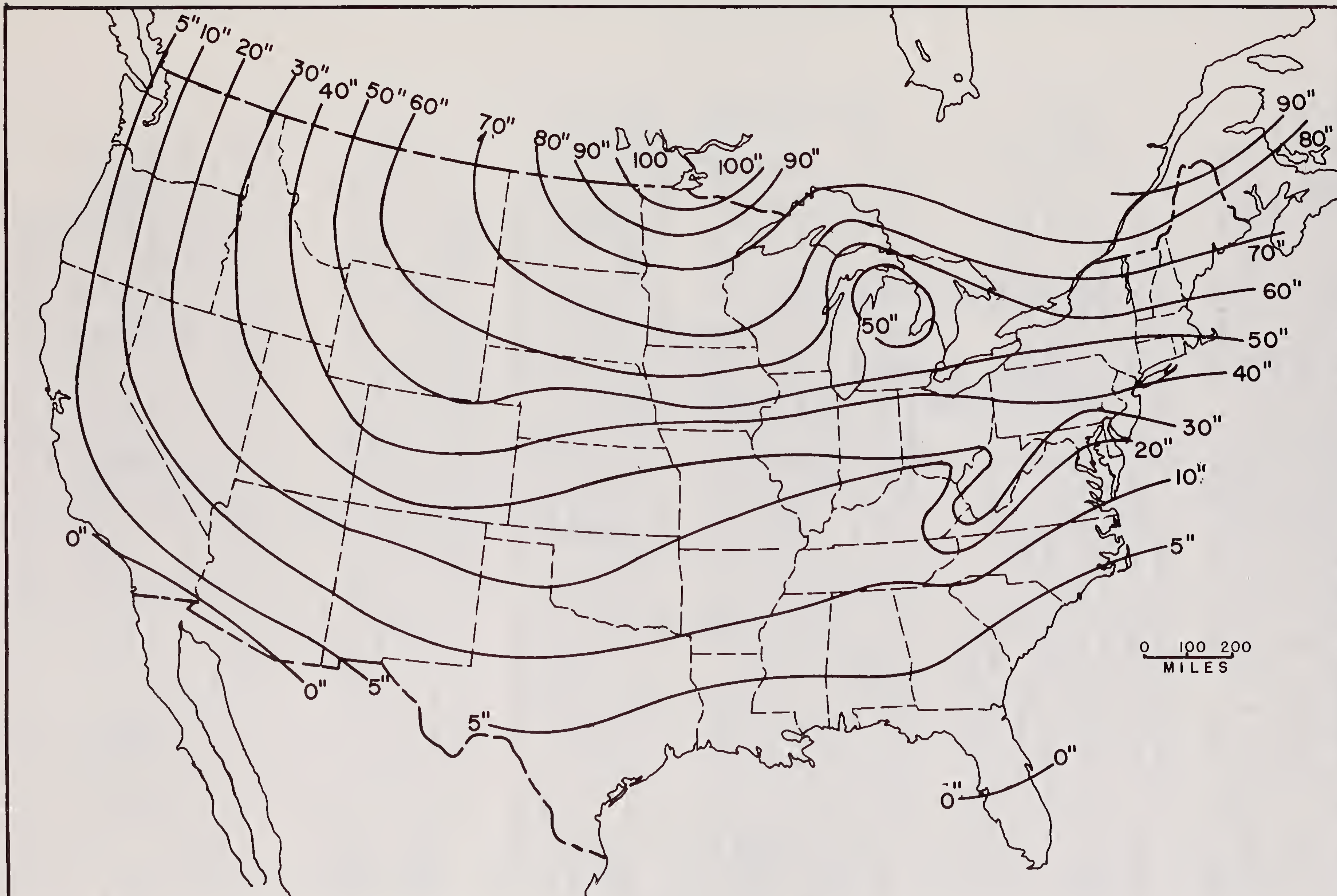

FIGURE 3. Extreme Frost Penetration in the United States
Source: U.S. Department of Commerce, Weather Bureau

relations exist for undisturbed soil. Within a shelter the temperature relations at different depths will be modified to some extent by the different heat properties of the air, and the contents and structural materials of the shelter. Nevertheless, a temperature gradient within the shelter will exist and it can cause moisture migration problems.

It is estimated that the average temperature of a shelter of the design described, and built at such a depth that the ground surface above the shelter is level, will approximate the temperature at the 10-foot soil depth. In a situation such as that shown in Figure 2, the shelter temperature would range from a minimum of 37 degrees at the beginning of April to a maximum of 53 degrees at the beginning of October.

Average monthly air temperature and soil temperature at the 10-foot depth for southern locations are plotted in Figures 4, 5, and 6. In these areas there is less fluctuation in both air and ground temperatures. The difference between the average temperature and the maximum or minimum temperature at the 10-foot depth is 5 degrees at Memphis, 3 degrees at New Orleans, and 2 degrees at Miami, compared to the 8 degrees at St. Paul.

In shelters with 15 feet or more cover, a constant temperature equal to the average annual air temperature can be assumed. Underground garages, subways, the upper levels of many mines, and deep service tunnels fall in this class. Added heat or ventilation with outside air at ambient temperatures would modify the situation.

If a shelter is built partially above ground or completely above ground and then covered with soil, the temperature variations within the shelter will be greater than in shelters completely underground. The temperature fluctuations may be similar to those at the 6-foot and the 3-foot soil depths.

The temperature of shelters in basements of buildings will be greatly influenced by heating and air-conditioning practices in the building. If the building is unheated the shelter temperatures will approximate those for underground shelters. The effects of insulation and heat absorption by soil over a shelter is duplicated to a considerable extent by the walls, floors, and contents of the building. If the building receives heat, the average annual temperature for such a shelter would generally exceed the maintained heating temperature (in winter).

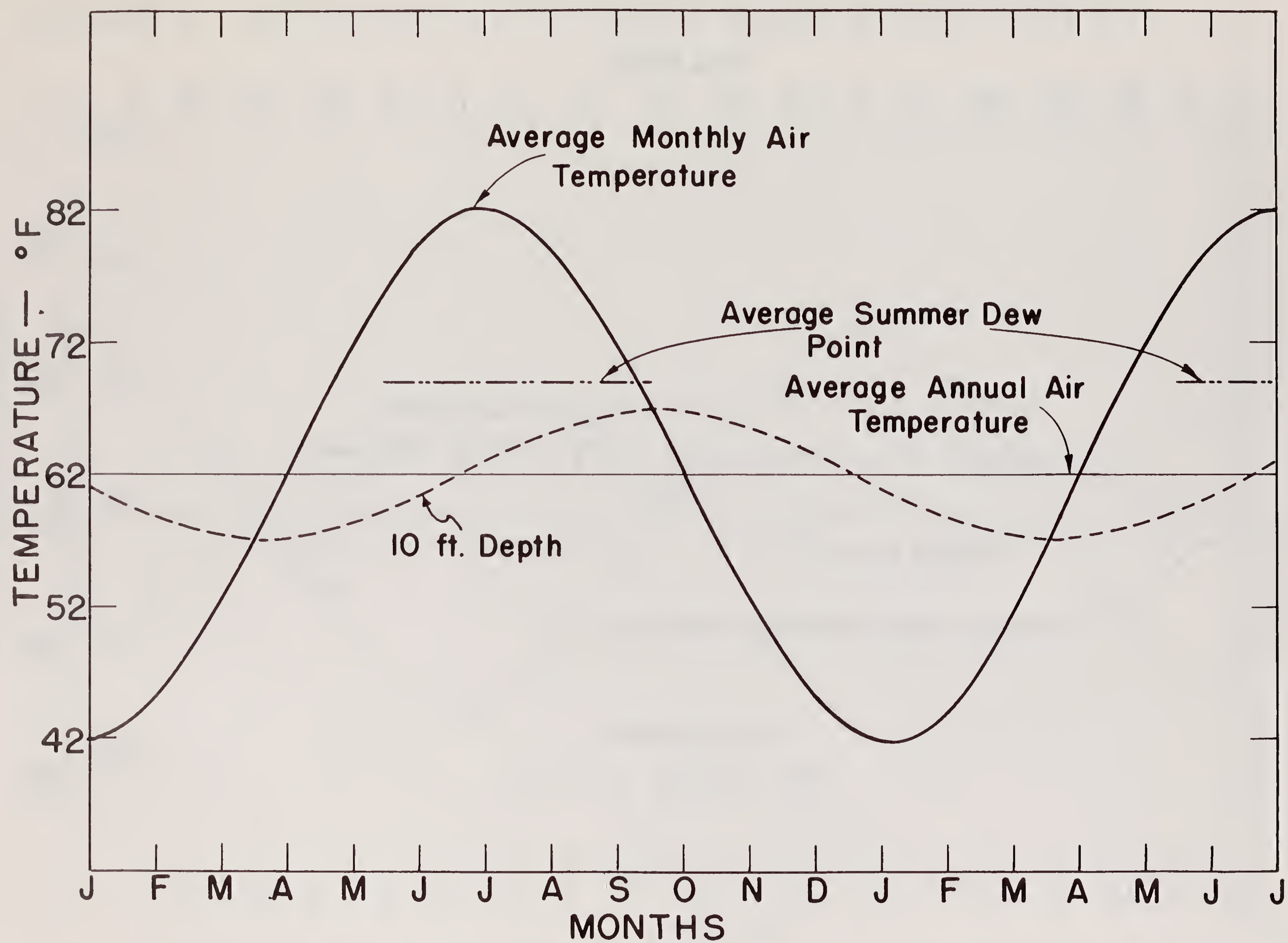

FIGURE 4. Air and Soil Temperatures at Memphis, Tennessee

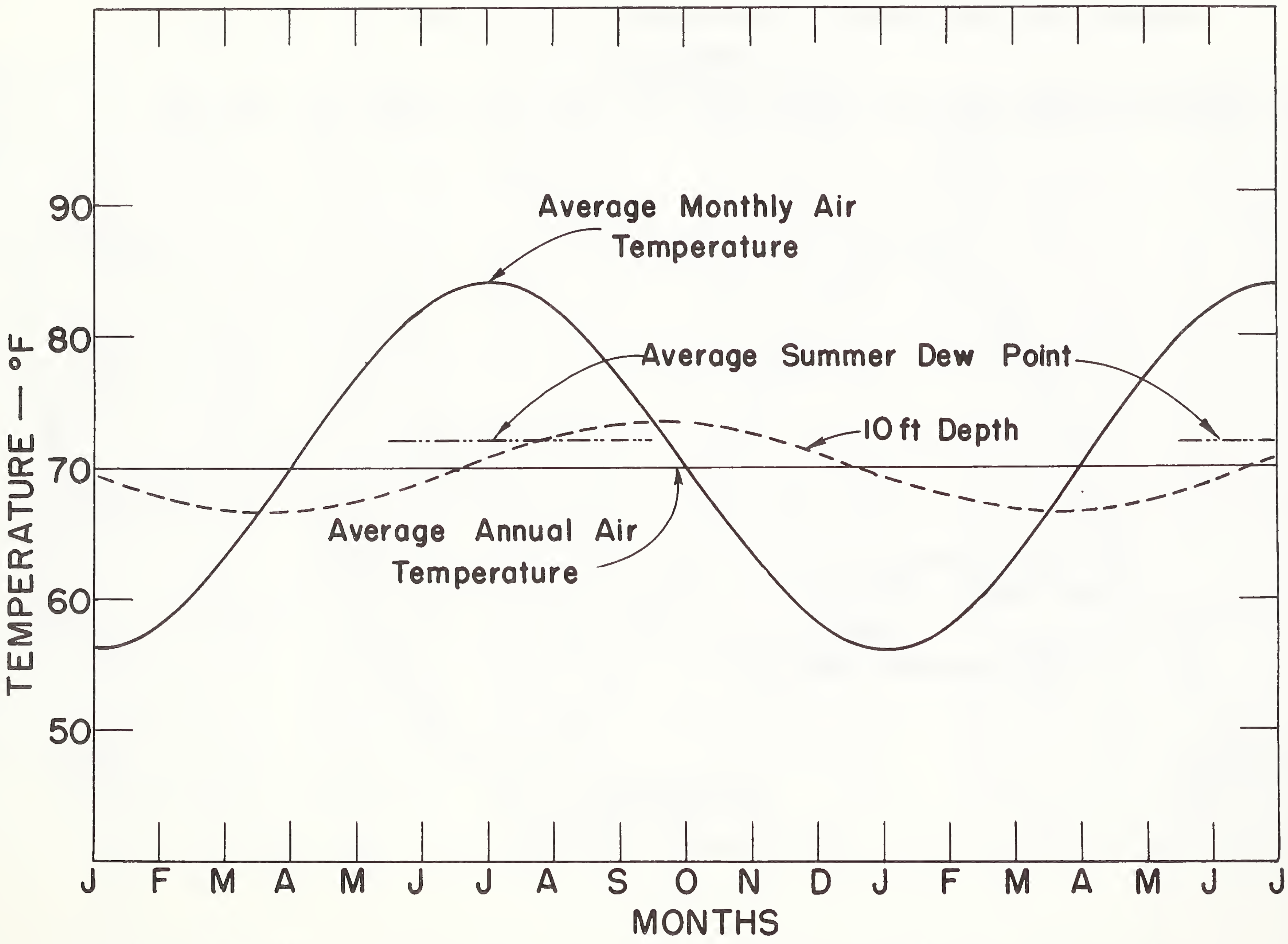

FIGURE 5. Air and Soil Temperatures at New Orleans, Louisiana

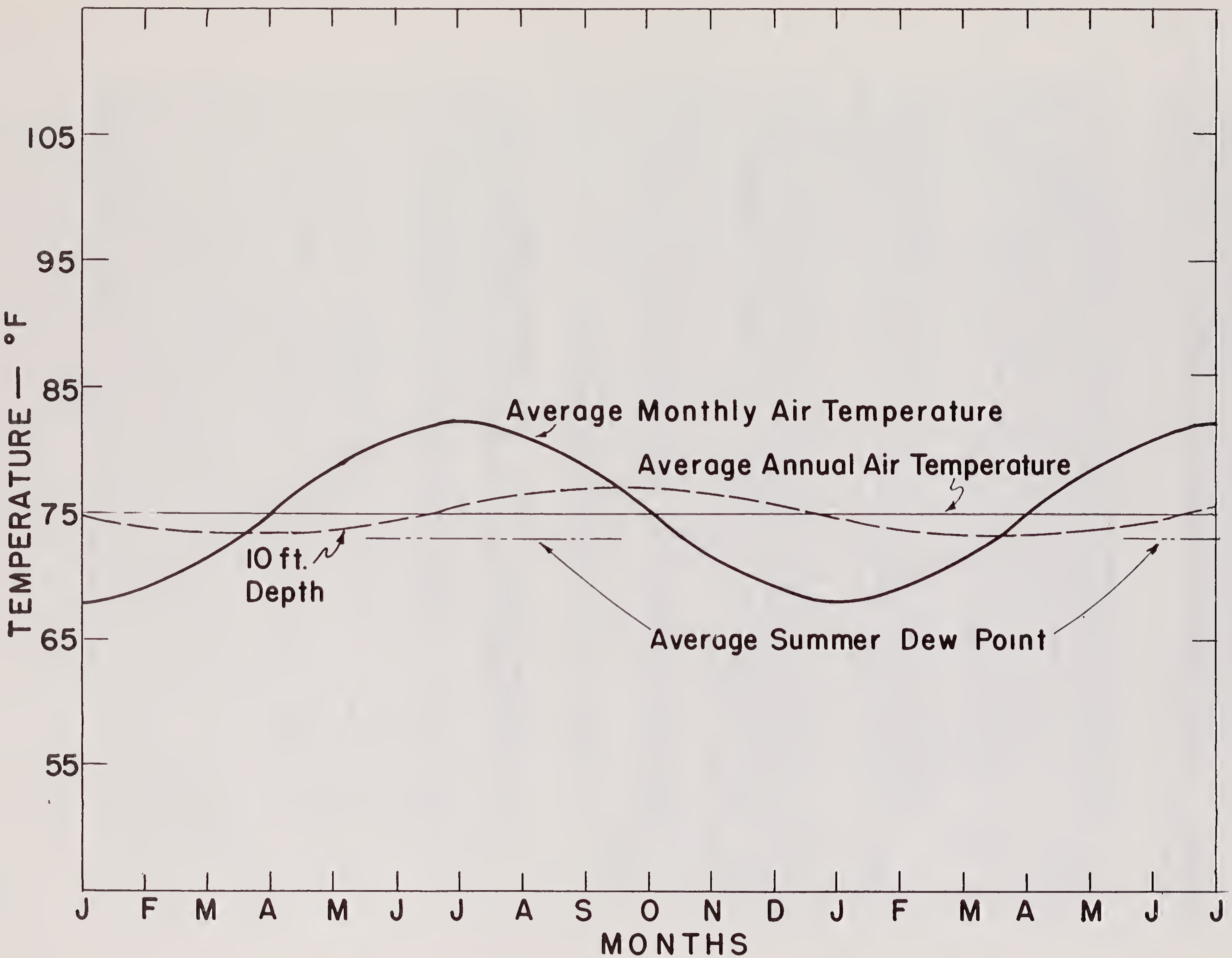

FIGURE 6. Air and Soil Temperatures at Miami, Florida

Space next to furnaces, boilers, heating pipes, and other sources of heat should not be used for food storage because of accelerated deterioration caused by these high temperature sources.

Temperatures in home shelters will be similar to those for shelters in other buildings except that the effects of insulation and heat absorption by the walls, floors, and contents of the house will be smaller than in the larger industrial buildings. Temperature fluctuations will be greater but the average would be the same.

Humidity is the second major factor in shelter environment that affects storage life of food products; particularly, moisture will induce deterioration of the packaging used for the food. The package must, by its chemical and physical stability, be able to withstand the effects of humidity and also, by its resistance to the passage of water vapor, be able to protect the food from adverse changes caused by moisture.

Moisture may enter the shelters from any of several sources:

1. Water in construction materials.

2. Leakage through walls, ceiling or floor, or by flooding through entrances or ventilation ports.

3. Moisture vapor from diffusion through walls, ceiling, or floor.

4. Water in materials being stored.

5. Moisture vapor in air entering the shelter.

Water in liquid form can be removed from a shelter by draining or pumping. Water vapor can be removed by relatively dry air flowing through the shelter or by mechanical dehumidification.

Construction materials may contain large quantities of water which, during the early life of a shelter, could be a severe problem. Concrete may require months of drying before the water content is sufficiently low so that it does not keep the humidity high in the shelter. Before a new shelter is stocked it should be operated for several days in the same manner that it will be during the standby period. The humidity should be checked to see that it does not rise to levels excessive for the materials that will be in the shelter.

Many underground structures may be subject to flooding from storms, ground seepage, broken water lines, etc. Such occurences may require early replacement of some or all of the stored foods, depending in part on the type of package protecting the food. Water entering the shelter by leakage or flooding should be confined to as amall an area as possible and then removed promptly. If it is allowed to remain over an appreciable area the humidity will build up to an intolerable level.

Entrance of moisture into shelters by diffusion through the shelter walls, ceiling, and floor will occur in most parts of the country. Any shelter that is located in moist earth and in which proper humidity is maintained for food storage will have moisture entering by this method. There may be no visible sign of moisture. In shelters that are not dehumidified the amount entering can be determined by humidity and airflow measurements. In dehumidified shelters it can be determined by measuring the amount of condensate from the dehumidifying equipment. (These determinations assume that moisture is not entering the shelter from other sources.) The quantity of moisture entering by diffusion can be reduced to a negligible level by proper construction. If the problem is found after the shelter is constructed, the quantity of moisture entering may be greatly reduced by coating the inside surfaces of the shelter.

Items stored in the shelters may contain water that can evaporate during storage and thus affect the humidity. Cellulosic materials, such as fiberboard used for cartons, wood for boxes, and cotton for bedding, are the most likely carriers of this water. Green wood may contain water up to three times the dry weight of the wood. Any cellulosic materials that have been air-dried or allowed to come to equilibrium with the surronding air may still contain an appreciable quantity of water. Figure 7 shows the equilibrium moisture content of wood at various relative humidities. For example, if wet wood is placed in a shelter held at 70 percent relative humidity the wood will dry down to 12 to 13 percent moisture. While the quantity of moisture that might enter a shelter by this method is small, it is quite significant in some instances.

Moisture can be gained or lost by air movement through the shelter; the direction of shift depends on the moisture content of the entering air and the conditions, primarily temperature, within the shelter. Moisture will be gained in the summer when the outside air contains a large quantity of water vapor. Shelter temperatures will be below the outside air temperatures so that air entering the shelters will be cooled. This cooling increases the relative humidity. Any materials capable of absorbing water will take in additional moisture. If the air is cooled sufficiently it reaches 100 percent relative humidity. The temperature at which this occurs is called the dew point. Any cooling below this point causes condensation of moisture. This condensation normally occurs on surfaces that are cooler than the air, and the moisture may cause rapid deterioration of many materials.

Moisture will be lost from the shelter during cool days when the amount of water vapor in the air is small. Shelter temperatures will be higher than the outside air temperature so that air entering the shelter will be warmed. This decreases the relative humidity of the air. Materials with absorbed moisture will dry and the rate of evaporation of any water in liquid form, such as surface condensation, will be increased.

The important influence of air circulation on humidity levels in shelters is illustrated by data in Table 1, where average annual air temperatures can be compared with average summer dewpoints (columns 1 and 5) at many locations in the United States. As stated earlier, the average temperature in a shelter is approximately the same as the average annual air temperature. In late summer and early fall, shelter

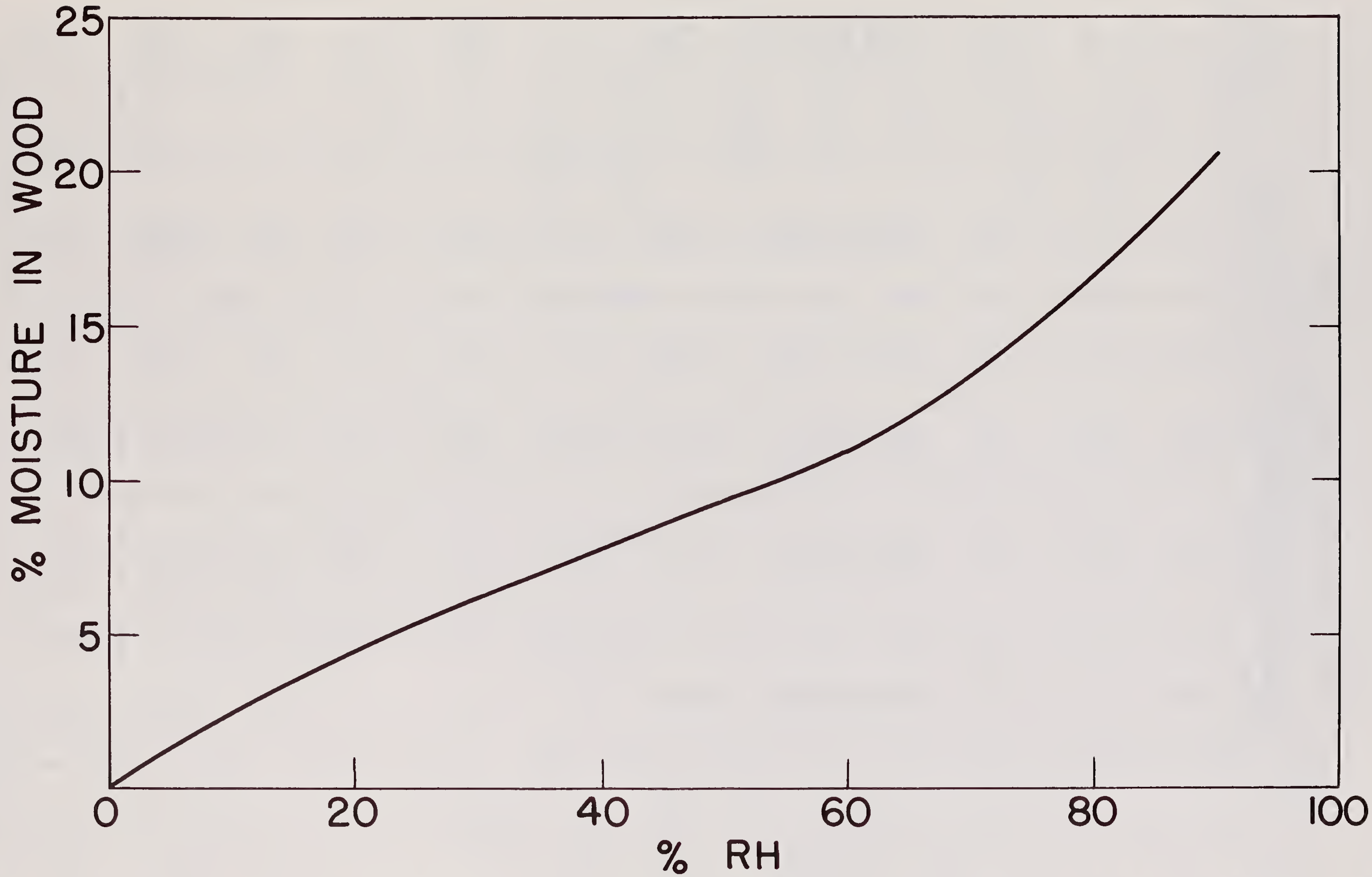

FIGURE 7. Equilibrium Moisture Content of Wood at Various Relative Humidities
Source: Wood Handbook, U.S. Department of Agriculture Handbook No. 72, 1955

TABLE 1

Air Temperatures, United States

	Av. Temperatures, °F. Annual	January	July	Range	Average S.D.P.[1/]	Hours D.P.≧A.T.[2/]
Alabama						
Mobile	68	53	82	15	71	2478
Arizona						
Phoenix	71	51	90	20	53	66
Arkansas						
Little Rock	62	42	82	20	68	2500
California						
Fresno	63	45	82	18	49	24
Laguna Beach	61	53	71	8	59	1060
Oakland	57	48	63	9	53	300
San Diego	62	55	69	7	60	1194
Williams	60	45	77	15	50	211
Colorado						
Denver	50	31	74	19	44	875
Grand Junction	52	24	78	24	40	504
D.C.						
Washington	56	36	78	20	65	1934
Florida						
Jacksonville	70	57	82	13	72	2328
Miami	75	68	82	7	73	790
Georgia						
Atlanta	62	45	79	17	66	2327
Idaho						
Boise	51	27	75	24	42	385
Illinois						
Chicago	50	25	75	25	58	2414
Moline	50	24	74	26	60	2574
Indiana						
Evansville	57	35	80	22	65	2484

1/ Summer dew point.

2/ Dew point equal to or greater than average annual temperature.

TABLE 1 (continued)

	Av. Temperatures, °F.				Average	Hours
	Annual	January	July	Range	S.D.P.	D.P. ≥ A.T.
Kansas						
Wichita	57	30	81	27	58	1838
Louisiana						
New Orleans	70	56	83	14	72	2423
Shreveport	67	47	83	20	69	2314
Massachusetts						
Boston	51	29	72	22	58	2501
Michigan						
Detroit	49	26	73	23	57	2466
Minnesota						
St. Paul	46	15	74	31	56	2542
Mississippi						
Jackson	65	53	81	12	70	2508
Missouri						
Kansas City	56	30	81	26	61	2254
Kirksville	53	27	77	25	60	2378
St. Louis	57	33	81	24	61	2112
Springfield	56	33	77	23	63	2466
Montana						
Helena	43	19	67	24	42	1300
Nebraska						
North Platte	50	24	76	26	55	2214
Omaha	52	23	78	29	60	2429
Nevada						
Elko	46	24	70	22	28	152
Reno	50	31	70	19	38	144
New Jersey						
Camden	55	35	77	20	61	2361
Newark	53	32	75	21	61	2517
New Mexico						
Albuquerque	57	34	79	23	47	484

TABLE 1 (continued)

	Av. Temperatures, °F.				Average	Hours
	Annual	January	July	Range	S.D.P.	D.P. ≧ A.T.
New York						
Albany	47	25	73	22	56	2509
Buffalo	48	25	71	23	54	2194
New York	54	33	75	21	61	2405
North Carolina						
Raleigh	60	43	79	17	66	2544
Wilmington	64	48	80	16	70	2472
Ohio						
Cincinnati	54	35	78	19	62	2477
Cleveland	51	29	74	22	58	2259
Oklahoma						
Tulsa	61	38	83	23	64	2207
Oregon						
Portland	54	39	68	15	52	1220
Pennsylvania						
Bellefonte	51	29	73	22	58	2378
Pittsburgh	52	33	75	19	58	2283
South Carolina						
Charleston	66	51	81	15	71	2600
South Dakota						
Huron	46	13	75	33	52	2146
Rapid City	46	21	72	25	47	1634
Tennessee						
Knoxville	59	40	80	19	64	2474
Memphis	62	42	81	20	69	2346
Texas						
Amarillo	57	35	78	22	55	1730
Brownsville	74	60	84	14	73	1339
Dallas	67	46	85	21	66	1809
El Paso	63	45	81	18	50	181
Houston	70	53	84	17	71	2423
San Antonio	69	51	84	18	68	1677
Utah						
Modena	49	26	71	23	35	469
Sal Lake City	52	29	78	23	40	360

TABLE 1 (continued)

	Av. Temperatures, °F.				Average	Hours
	Annual	January	July	Range	S.D.P.	D.P. $\geqq$ A.T.
Washington						
Seattle	52	41	66	11	51	1288
Spokane	47	25	70	22	41	667
Wisconsin						
Green Bay	44	16	70	28	55	2517
LaCrosse	46	16	73	30	59	2662
Wyoming						
Rock Springs	43	19	69	24	32	504

Sources: (2, 48, 57, 62)

temperatures may be slightly warmer than the average annual air temperature, depending on the depth of the shelter and its geographical location, but for the purpose of the following discussion it is sufficiently accurate to consider them equivalent.

In many localities, shelter temperatures (equal to annual average, column 1, Table 1) would be below the dew point (column 5) in the summer. Condensation of moisture on walls and contents of shelters will occur. Column 6 shows the number of hours during the summertime (June 1 to September 30, or 2928 hours) that the dew point of the outside air is above the shelter temperature. In general for Eastern, Central, and Southern areas, the dew point is higher over 75 percent of the time. Pacific Coast areas not immediately adjacent to the sea and the Mountain States show much more favorable relationship between summer dew point and shelter temperatures.

If the shelters are to hold materials for which a humidity of less than 70 percent is recommended for good storage life, the problem is greatly increased. For the effect of this requirement, the dew point data should be compared with a temperature about 10 degrees below the annual temperature. Only the desert areas have more than half of the summer hours in which the dew point is below this lower temperature.

Closing a shelter tightly would, of course, prevent moisture increase from outside air. However, moisture vapor from any of the other sources listed will not have any way to get out of shelters that are not dehumidified. It is doubtful that many shelters would be built so that moisture could not get in. The

build-up of moisture in most shelters, if they were shut tightly, would soon result in a relative humidity approaching 100 percent.

Selective ventilation offers one way of counteracting excessive humidity if there are periods during which the humidity of the outside air is not excessive. By preventing ingress of moisture to the shelter as much as possible and running ventilating equipment on days when the humidity is favorable, it may be possible for some shelters in high humidity areas to maintain acceptable humidity levels during all or most of the time. Ventilation during the summertime will raise the shelter temperature to some extent. While an increase in temperature is favorable in counteracting the humidity problem it is detrimental to storage life of foods.

In commercial warehouses, selective ventilation and heating are commonly used to counteract the increase in moisture vapor that occurs in spring and summer. On warm days of low humidity, air is circulated through the warehouse to warm up the stacks of foods. Supplementary heat may be used to increase the temperature rise of the stored materials if outside air temperature is not sufficient. By proper use of these steps, all chances of the relative humidity becoming too high can be avoided. It is doubtful if such practices will be used to an appreciable extent in shelters because of the close control required and the increase in rate of deterioration of the foods due to higher temperatures.

Mechanical dehumidification offers the best means of controlling humidity. If measures are taken to prevent ingress of moisture as much as possible, dehumidification may be one of the lowest cost methods of attaining long life for food containers and other equipment and supplies that deteriorate at high moisture levels. Refrigeration and rechargeable, desiccant-types of dehumidifying equipment are possible mechanisms for control of shelter humidity. The inexpensive, household-type, refrigeration dehumidifiers are generally inoperable below 65°F. which is above normal ground temperature for most of the northern United States. Where such units will function, they will maintain relativee humidity at 60 percent or lower. The rechargeable, desiccant-type dehumidifiers are generally more bulky and may be more expensive to operate and maintain than the refrigeration type.

In any event, provisions must be protected from moisture. If this cannot be accomplished within the framework of the shelter design and its maintenance program, then master containers or sealed and protected rooms can be used. These will be discussed in Chapter 3.

Air contaminants can have a major influence on corrosion rates of metals. The sulfur-bearing compounds---sulfur dioxide, sulfurous acid, sulfuric acid, and hydrogen sulfide --are the most frequent causes of excessive corrosion rates. Other harmful materials are hygroscopic dusts, nitric acid, carbon dioxide, ammonium chloride, hydrochloric acid, ozone, and possibly other smog components. Air contaminants are found primarily in industrial areas although ozone and other smog materials also come from heavy concentrations of automobiles or other equipment using internal combustion engines.

Salt sprays carried by ocean winds also cause abnormal rates of corrosion. Usually the areas affected are limited to those immediately adjacent to the water. The corrosion rates can change several fold in a distance of a few hundred feet.

No information is available on the amounts of these contaminants that might get into shelters and cause increased deterioration rates. More frequent inspections will be justified for shelters built in industrial areas and near the seashore.

Insects and rodents can constitute a hazard to goods stored in shelters. Some of the underground shelters in the most northerly states may be sufficiently cold that insects will not be a problem. Underground shelters in other areas and all above-ground shelters will have temperatures permitting the growth of insects. All the packaging should be resistant to insects and rodents.

Repellants and pesticides would need to be reapplied periodically. To the extent possible, shelters should be constructed to keep vermin out.

Chapter 3. STORAGE STABILITY OF FOOD

Commercial Food Distribution Practices

A common misconception exists that dry groceries found on market shelves are nonperishable. To the contrary, foods of all kinds are perishable, and shelter stockpiles should be selected with some knowledge of degree of perishability in order that satisfactory food will always be available and total costs will be minimal. (The problems of surveillance raised by the perishable nature of food and replacement of deteriorated supplies are discussed in Chapter 4.) The misconception concerning perishability of food arises from normal marketing and use patterns. Canned goods and dry groceries are revolved so rapidly through the grocers' shelves that their lack of stability is rarely detected. Table 2 illustrates the normal supply of various food items held in wholesale storage and in the average large, medium, and small retail store in terms of rate of stock turnover.

TABLE 2

Inventory of various types of food normally carried at wholesale and retail trade levels.

Food Items	Wholesale	Retail Store Stock		
		Large	Medium	Small
Canned fruit and vegetables	3 months	1-2 months	1-2 months	4-6 weeks
Flour	1 month	2-3 weeks	2 weeks	2 weeks
Sugar	3 days	1-2 weeks	2 weeks	1-2 weeks
Coffee	1 month	2-3 weeks	2 weeks	3-4 weeks
Other beverages	2 months	3-4 weeks	3-4 weeks	1-2 months
Evaporated milk	1 month	2 weeks	3 weeks	2 weeks
Canned soups	3 weeks	2-4 weeks	2-4 weeks	2-4 weeks

Source: Private communication, Retail Grocers Association of San Francisco, Ltd.

The method of canned food distribution has changed progressively during recent years. For many years canned food products were shipped from the packer's warehouse to the distributor's warehouse shortly after packing. This procedure required the distributor to carry large inventories for local distribution in his area. At present the majority of canned food products are warehoused by the packer and shipments are made as requested by the distributor. The method permits more uniform storage conditions in a packer's warehouse designed for the purpose than could be obtained in various localized distribution centers. It also reduces freight, rehandling, and numerous other costs.

Military and other Government agencies distribute food in a similar manner. For continental use, most military and Federal specifications authorize commercial packing as being acceptable unless otherwise specified. The shipments are made to Government operated warehouses or depots, and the food is distributed from there as required. The time under warehouse storage and rate of turnover is about the same as for domestic storage and retail sale. For special rations, overseas use, or wherever storage life becomes important, other forms of packing and packaging are required.

Any food that maintains a reasonably good quality for more than a year will generally be consumed before deterioration is noticeable and for ordinary commercial purposes is nonperishable. For less stable foods, inventory controls are developed to achieve rapid sales turnover, hence the general public is unaware that these food are quite perishable. Many foods requiring no unusual handling for normal marketing would, by the end of two years of commercial handling, be tainted by products of deterioration, substantially diminished in nutrient quality, and even spoiled by corruption of their packages. After long-term storage, such as envisioned for shelter stockpiles, the perishability of foods will be manifest. If indeterminate or long-term storage is requisite for shelter stockpiles, very few items of normal domestic markets will be useful.

Relative Stability of Various Food Classes

Woodroof (61) has reviewed the literature concerning stability of foods. There remains to be said here only those general statements on food stability that point up the many problems in selection of food stockpiles for shelters, in management and maintenance of the stockpiles during the standby period, and in the utilization of the food during an emergency.

Highly refined foods are generally the most stable. With adequate package protection there will be no deterioration of salt or sugar for very long periods. Unprocessed cereals and seed foods (e.g., beans and peas) also have very long storage life if protected from insect infestation and moisture. Thus, if packages remain sound and if moisture content is not such as to promote deterioration, the refined foods and unprocessed cereals and seed-foods will retain acceptable food quality for 20 to 50 years at reasonable temperatures, such as 70° F. Some fermented beverages have a very long shelf life. Milled and ground cereals may also have a very long shelf life although they are more subject to oxidative changes than unprocessed cereals.

Dehydrated foods, as a class, are very stable. With proper control of moisture content and with formulation and packaging to resist oxidation and browning types of deterioration, stability of 5 to 10 years should be attainable by many foods suitable for shelter use. It must be admitted that very few foods exist in today's markets that have been subjected to research that would lead to formulations maximizing stability. However, soluble coffee and tea are attributed with very long shelf life and examples are known of instant puddings and dehydrated vegetables being highly acceptable after 7 to 10 years in storage at temperatures of 70° F. and higher.

Preserved foods of high moisture content, such as most canned foods, tend to have a short shelf life, principally because metal containers corrode and affect the quality of the food or the integrity of the container (container corrosion will be discussed in greater detail below).

Many known chemical reactions or reaction types are involved in the perishability of foods. Such reactions are subject to physical conditions that determine their rates, the most important factor being temperature. As a general rule,

the rate of chemical reaction is doubled by a 15° F. rise in temperature in the range that would be important to shelter provisioning. Stated another way: a stored food that has a shelf life of two years at 70° F. (this would include most canned fruits as packed for domestic markets) would have a one-year shelf life at 85 degrees, but a four-year shelf-life at 55 degrees. Thus the control of temperature to low levels will greatly prolong shelf life of foods. Refrigerated or air-conditioned shelters or food storage areas would materially reduce the recurring costs for surveillance and replacement of food supplies. In the absence of adequate information on the long-term storage of foods appropriate for shelters, this simplified statement of the effects of temperature on storage life is useful in anticipating surveillance activities (discussed in Chapter 4), provided one has a reasonably certain knowledge of temperature conditions of individual shelters.

Packaging to meet External Conditions

Package failures may occur because of adverse temperature and humidity conditions, mechanical hazards in transporting and handling, faulty materials or construction of the package, and damage by insect or rodent pests.

In many shelters, temperatures will be lower than those found in trade channels and, therefore, will tend to lengthen shelf life. However, high humidities and surface condensation in many shelters will be extremely detrimental to most metallic or cellulosic materials, whereas humidities are controlled by one means or another in normal trade.

For many metallic materials, there is a critical level of humidity above which some corrosion may be anticipated and below which corrosion is unlikely to occur. The critical level may fall appreciably below saturation of the air due to factors such as temperature, impurities in the air, or contamination, scratches, or stains on the metallic surface. Under severe conditions, such as seaside atmospheres, corrosion may occur at a humidity below the commonly accepted

critical level. For the tinplate surface of cans used for foods, the critical level is considered to be in the range of 60 to 70 percent relative humidity.

The criteria for acceptable packaging are different for commercial channels and shelters. Appearance of container is a major factor in marketing canned goods but may be of little importance for emergency stockpiles. Slight rusting of metal is considered a major defect by a retail customer but a shelter occupant would tolerate considerable external rusting of cans as long as the contents were not affected. Available data on rusting of tin cans are concerned with usual marketing circumstances and can be interpreted only in general terms for shelter circumstances.

As packages, tin cans have the greatest commercial usage for the types of food that may be acceptable for shelters. Tin cans stored in damp shelters may not have adequate durability. Among other factors, the resistance of cans to external surface corrosion is influenced by the composition of the base steel, the type and thickness of the tin coating, and the use of protective organic coatings. Tinplate is not particularly rust resistant and the increased resistance obtained by changes in composition of the base steel and the tin coating are relatively small. Only a very few instances have been reported where heavy tinplate has been satisfactory and light coatings not. An effective method to increase durability against external surface corrosion is by use of lacquer coatings applied to the cans either prior to or after filling. Coating the closed can after filling gives more protection than precoating; however, the latter is a major improvement over uncoated tinplate.

Rusting occurs quickly on bare tin cans where water has condensed, and rusting continues as long as water remains. Cans subject to such moisture will eventually fail, probably due to perforations. Published information does not tell the length of time required for perforations of cans under such conditions, and it is, therefore, not possible to predict how long cans may last under uncontrolled shelter conditions. If the relative humidity of shelters is maintained below the critical range of 60 to 70 percent, the exterior of cans will last indefinitely unless other unusual factors are involved.

Glass containers are used for a smaller variety of foods that are suitable for stocking shelters than are tin cans. The glass part of the container will have an unlimited

life relative to corrosion. However, glass is subject to mechanical damage including rupture which may be caused by freezing of some products and handling abuse. Metal lids are subject to the same corrosive deteriorations as tin cans, but usually they have enhanced durability because of their decorative organic coating and the heavier tin plate commonly used. Some glass containers have plastic or other non-metallic closures that should provide an almost unlimited life even under damp shelter conditions.

Aluminum cans are appearing on the market as containers for beer, orange juice and some other commodities. The value of aluminum for packaging shelter foods would depend on availability, cost, and shelf-life. At present very little applicable data are available on these factors.

Cellulosic materials absorb moisture to an extent dependant upon the relative humidity. (This is discussed in Chapter 2.) As moisture content increases in paper, fiberboard, and other like container materials, strength decreases. At high moisture levels so much strength may be lost that containers may be worthless. Mold growth and other microbial deterioration are usually negligible at 70 percent or lower relative humidity, but above 80 percent severe deterioration can be expected.

The use of films of many types for packaging foods is rapidly expanding. Of the films commonly used in commercial channels today, all of the plastics have too high a moisture transmission rate to be acceptable for long-term storage in damp areas. Aluminum foils have low moisture transmission but lack strength. More desirable films are obtained by various laminates made of plastics, aluminum foil, and paper. Even the best of these may have weaknesses through pinholes, punctures, or imperfect package seals. Some of the better types now being used have not been on the market for a period equivalent to the storage life desired for shelter stockpiles. Therefore, commercially produced units of these types have not been adequately tested to determine their potential for use in shelters. For these reasons, and because no film has been developed that cannot be penetrated by insects, the use of films as a complete container for foods cannot be recommended for shelter stockpiles held for long-term storage.

Master containers offer a possible method for protection of the external surfaces of food packages, even when storage atmosphere is adverse. Foods packed in containers

that are inadequate under the shelter conditions could be packed in larger containers that would be protective. Three general types of master containers are feasible: rigid metal containers such as 55-gallon steel drums, 5-gallon hermetically sealed cans, or large metal boxes; lined fiberboard drums; and flexible envelopes of a moisture resistant barrier, such as the Mil 131 type of plastic and metal foil laminate. Accidental rupture and imperfect sealing would tend to force the selection toward the rigid containers. Protection against pilferage and possible reuse of rigid containers to seal putrifiable wastes during shelter occupancy would also favor the drums. On the other hand, the flexible envelope might be less expensive and would use shelter space more efficiently because of package shape.

If large containers are not completely moisture-tight, a desiccant could be used to absorb moisture and protect the package or protect the food if individual packages are permeable. Desiccants include specially prepared calcined lime, montmorillonite clay, silica gel, and alumina. The amount of desiccant required depends on the tightness of the master container and the humidity conditions in the storage space. Where desiccants are used in connection with long-term storage they may require renewal at intervals and will enter into the surveillance program.

Internal Deterioration of Food Packages

A limitation to long-term storage for most commercially canned foods is the internal corrosion brought about by chemical interaction of the contents and container. This statement applies to wet foods only, because dry foods (moisture about 10 percent or less) do not induce interior corrosion of tin cans. Factors which may influence internal corrosion and other forms of can failure are numberous, extremely variable, and very complex. Important factors include: the chemical composition and physical properties of the base steel; the pretreatment of the base steel prior to tinning; the amount, or weight, of tin coating and the method of application; the nature of the inside enamel and whether or not enamel is used to coat the body and/or the ends of the can; the chemical composition of the solder, and whether or not the can side seam is striped; handling abrasion; the method of processing the product and the packing procedure employed; the

chemical composition of the product, that is, the kind and quantity of pigment, the type of acid, the corrosive character of the acid, the pH, etc.; the headspace atmosphere or vacuum in the container and the quantity of air or hydrogen acceptors present in the product; and the storage temperature.

The thickness of the steel base plate in the present small food cans ranges from about 0.006 to 0.010 inch. The thickness of tin coating ranges from 0.000100 inch for hot dip tinplate to 0.000015 inch for electro-tinplate and the average thickness of the organic enamel overlay is about 0.0003 inch. These layers are very thin and, consequently, the cans are vulnerable. Reports indicate that the tin-iron stratum and the tin coating proper are far from uniform in thickness and never free from holes and breaks.

A common form of deterioration is detinning of the cans which subsequently affects the quality of the contents. As cans corrode in the presence of acid foods, metallic tin goes into solution, and hydrogen may or may not be generated depending upon the nature of the acid and the tin salts formed. If hydrogen is evolved the cans will eventually perforate or rupture from the pressure buildup.

When the inner surface of the can is protected by an enamel coating, corrosion is likely to be confined to imperfections in the enamel film, and then pinholing may occur without substantial pressure increase. However, the rate of chemical activity taking place at a pinhole is much greater than the rate of a similar attack occurring over the total surface of a can, and perforation at a pinhole may occur rapidly and without prior visible external signs. Some enamels contain zinc oxide, purposely added, to react with the food acids. For example, the sulphides formed during the heat processing of certain protein foods react with the zinc to form white zinc compounds instead of the dark tin and iron sulphides. In other instances, plain tin exerts an action that protects the color of some products which otherwise would darken in a fully enameled can. Chemical attack of the zinc oxide pigment held within the enamel film may assist in the film breakdown and expose the metallic surface of the can to further corrosion, and contaminate the product with the pieces of enamel film.

The rate of can corrosion or the time required to produce can failure varies widely; the variation may be due to the nature of the product, the processing method, irregularities in can construction, or other unexplained factors. For

example, in a recent experiment (30), three commercial packers canned spinach in 1.00-pound electroplated tin cans and 1.25-pound hot-dip tinplated cans, each from a single manufactured lot. The rate of corrosion was measured by the time required for the first hydrogen swell to occur during storage at 100°F. In 1.00-pound electroplated tin cans, the first failures occurred at 14, 8, and 5 months for the products from the three different packers; in 1.25-pound hot-dip tinplated cans, the first failures occurred at 18, 13, and 13 months. The tin dissolved by the processed spinach after 12 months' storage at 70°F. was 65, 40, and 370 parts per million in the electroplated cans and 30, 30, and 50 p.p.m. in the hot-dip plated cans. Thus, even with identical cans and the same product, wide variation in perishability was noted but unexplained.

Technical progress in recent decades has changed and improved the chemical composition of the base steel and developed cold rolling of strip steel of the various gauges used for food containers. Industry is gradually replacing the hot-dip plating method by the cold electroplating process and recently has instituted differential electroplating. Much work has been done in formulating better enamels which are applied and baked on tinplated steel in a continuous operation.

Such changes however have not been made as a means to increase the shelf life of canned foods; in fact, a decrease has resulted. In the face of rising costs, the aim of the industry is principally to realize a saving in labor and material costs in the production of metal containers designed to meet market requirements with a sufficient margin of safety, and all that is required is a one- or two-year shelf life. Changes since 1944 in the packaging of various fruit and vegetable products and the effects of these changes on shelf life of the commodity are shown in Table 3. The 1.25-pound and 1.50-pound plates are hot-dip tinplate and the 1.00-pound and lower are electrotinplate. Generally speaking, the lower the pH the shorter the shelf life and the heavier the tinplating required.

A current saving of tin ranging from 20 to 80 percent is indicated (Table 3). The reduction in shelf life however ranges from 25 to 80 percent of that expected for the same commodities packed fifteen years ago. The

TABLE 3

Recent changes in tin cans and the resulting effect on shelf life of various food products.1/

Canned Item	pH	1944 Tin Coating		1944 Shelf-Life 2/	1958 Tin Coating		1958 Shelf-Life 2/
		Body	Ends	Months	Body	Ends	Months
Apples	3.4	1.50#	0.50#	36	1.00#	0.25#	18+
Applesauce	3.3	1.50#	0.50#	36	1.00#	0.25#	12
Apricots	3.7	1.50#	1.50#	36	1.00#	0.25#	18+
Blackberries	3.5	1.50#	1.50#	12+	1.50#	1.50#	12
Cherries, sweet	3.4	1.50#	1.50#	12+	1.00#	0.25#	6-12
Fruit Salad	3.8	1.50#	0.50#	36	1.00#	0.25#	24
Grapefruits	3.2	1.25#	1.25#	36	1.00#	1.00#	12
Peaches	3.7	1.50#	1.50#	36	1.00#	0.25#	18-24
Pears	4.2	1.50#	0.50#	36	1.00#	0.25#	24-36
Pineapples	3.7	1.25#	1.25#	36	1.00#	1.00#	24
Beans - Lima	5.9	0.50#	CTB 3/	96+	0.25#	0.25#	18-30
Carrots	5.2	1.25#	CTB	36+	1.00#	0.25#	18
Corn	6.3	0.50#	CTB	96+	0.25#	0.25#	36
Peas	6.0	0.50#	CTB	96+	0.25#	0.25#	18-36
Spinach	5.4	1.50#	CTB	36+	1.25#	0.50#	12-18
Tomatoes	4.3	1.25#	1.25#	48+	1.00#	0.25#	24-60

1/ Sources: Data for 1944 in references 3 and 14; data for current practices from various sources.

2/ Shelf Life at 70°F.

3/ CTB: Chemically treated black steel plate ordered as a tin-conservation measure by the War Production Board during World War II.

current average shelf life is about 24 months, with variations for some food items ranging from 6 to 12 months above or below the average. In general, canned foods as currently packed for domestic markets are not considered suitable for long-term storage as shelter rations, nor are they so intended.

In most instances, foods packed in 1.25- or 1.50-pound hot-dipped tinplate would have longer shelf life than foods currently packed for domestic sale. If such containers were used and protected from external corrosion, a 5-year shelf life would be expected for a few foods which are suitable for shelter provisions and 10 years might be expected for some. It should be pointed out that such packing is not generally available, except by special procurement and at a higher cost.

Glass as a food container has numberous advantages over cans. Glass is inert chemically and does not react with foods to produce flavor changes. It does not rust, tarnish, or disintegrate. If the jars are stored in an upright position, the contents are not in contact with the metal lids and internal corrosion is minimized. The contents in glass are visible. For some products, a visual inspection may be found to correlate with quality and be useful for surveillance without product destruction. Furthermore, glass containers can be obtained in a large variety of shapes and sizes, and the technology of packing food in glass is well developed.

Numerous wet foods packed in glass can be found on the open market, but most of them are of no prime importance for shelter rations. For example, fruits for salad, spiced apples, plums, pickles, and other specialties are available in glass. They generally have good shelf stability but are rather expensive. On the other hand, many items that can and have been packed commercially in glass, and which would be suitable for shelter stockpiling are not generally available in domestic markets at present, for the following economic reasons: the cost of glass packing is higher than tin; the number of cans packed per case is usually twice the number of glass units of equal capacity per case, which entails additional handling and packaging costs; and glass containers weigh more which increases transportation and handling costs.

Glass packing of commodities suggested as suitable for long-term shelter storage would require special procurement at a higher cost. However, in view of surveillance and replacement costs, glass packaging may very well have an important place in shelter provisioning. But it is necessary to consider another factor which discourages the use of glass for packing shelter foods, that is, the hazard of breakage in a crowded shelter.

Chapter 4. FOOD SURVEILLANCE DURING THE STANDBY PERIOD

Effect of Standby Period on Shelter Plans

Foods in shelters will deteriorate, even under the best possible storage conditions. If shelters are to be stocked over an indeterminate period with foods that are not rotated regularly into some normal use, then plans must be made to inspect stored stocks and replace them before they become unacceptable.

The recurring cost of shelter management during the standby period will be sizeable and should be anticipated as one of the unavoidable costs of the shelter program. The entire shelter, its equipment, and supplies must be maintained in functional condition for an indefinite period.

For greatest economy, management of the food supply during the standby period should be integrated with maintenance of ventilation, sanitation, and power generation equipment and with medical and comfort supplies. It is not feasible to isolate the food maintenance activities from the general shelter management, so costs cannot be accurately estimated. Where possible, some indication of the magnitude of recurring costs for food surveillance will be made so that they can be considered in relationship to the entire shelter program.

The problems and the costs of surveillance and replacement of food products will influence the food selection. General instructions can be given to keep recurring costs of shelter management low:

1. Stock inexpensive foods to minimize replacement costs.

2. Select stable foods to reduce the frequency of replacement.

3. Limit the variety in the ration in order to reduce the number of different products that need be evaluated at each inspection period.

Shelter food storage space should be designed and stockpiles arranged with a specific ration selection and management program in mind. If products are arranged in the storage room on the basis of food deterioration rates, the more stable ones could remain undisturbed during some inspections. Products of

differing deterioration rates should not be packed in the same master container, as is necessary with packaged complete meals used for Army combat rations. In addition, products of unequal hygroscopicity must be separately packaged to prevent moisture migration. It seems reasonable that the arrangement of food stockpiles for simplified sample-taking at repeated intervals over a possibly prolonged standby period would be less costly and inconvenient than arranging stockpiles for convenience at the time of their ultimate use. In either case, the fewer products in the stockpile the less the inconvenience, both for inspection during the standby period and use under emergency conditions.

Development of a rational surveillance program is necessary to reduce the risk of wasteful rejection of supplies that are still suitable or, alternatively, the risk of encountering a disaster with food supplies deteriorated beyond the point of acceptability.

Sampling Plans

Sampling plans exist for use in evaluating the quality of manufactured or purchased products. They are called "standard acceptance sampling plans" (54) and have been widely used in government purchasing as well as in industrial quality control activities. The procedure involves three steps:

1. Representative samples of a product are withdrawn from the stockpile in accordance with a selected sampling plan.

2. The samples are evaluated.

3. A decision is made to accept or reject the entire lot of the product from which the samples were taken.

Acceptance sampling plans can be applied to the quality evaluation of stored products by repeated use of the plans over prescribed time intervals. When used for this purpose they are called "surveillance sampling plans" (11). In the case of surveillance sampling, the decision that is made is to retain the lot in storage or discard it and replace with fresh stocks. The aim of the surveillance plan is to maintain at all times a food stock with a preassigned level of quality.

A set of rules must be constructed for surveillance inspectors. Ideally, a manual of surveillance sampling plans, applicable to the various ration components over the expected range of shelter conditions, would be made available to local shelter managers or their inspectors. The manual should contain a multiple cross-index, categorized by product, shelter temperature range, and lot size. (The term "lot" is used here to mean all of one product stored in one shelter.) By the index, the appropriate surveillance sampling plan would be selected for each product of a given shelter food stockpile. The plan would indicate when samples should be taken, how large a sample should be taken, what evaluation method should be used, and at what quality level (by the measurement) the lot should be replaced. At the time of initial stocking of the shelter, the manager or inspector would use the surveillance sampling plans to schedule his inspection tours and to guide the arrangement of products in the storage space.

Some modification of this sampling procedure is possible. "Truncated surveillance sampling plans" include replacement of the stored food at a predetermined calendar date. The sampling plan would be used to inspect the product at intervals to detect unusually fast deterioration (perhaps due to high temperature or an unstable lot), but the product would be replaced arbitrarily after a time that is considered suitable in relation to cost of product, cost of evaluation, and importance of the risk of not maintaining supplies in good condition. Such plans are called "truncated" because the plan is cut off regardless of the quality on the replacement date.

A special type of truncated plan is one without intermediate sampling and evaluation. If the product were inexpensive and of a very small lot size, and if its evaluation costs were high, or if its storage characteristics were well known and dependable, it might be economical to estimate optimum storage life and replace the lot without intermediate inspection.

Information Required to Make Efficient Surveillance Plans

Surveillance sampling plans represent an advanced area of statistical quality control. The development of such plans, including the truncated plans, require specific knowledge of six factors:

1. The kinds of foods to be stocked in shelters. Ration selection for shelter provisioning is, at present, less than tentative. (Proposals are discussed in Chapter 3.)

2. The amount, or "lot size," of each product to be stocked. The lot size will depend upon the number of different products in the shelter ration, the amount of ration stocked per shelter occupant, and the rated shelter capacity. If, for example, shelter sizes range from 30-man to 100-man capacity and if, furthermore, the variety of food stocked is great, then the quantity (lot size) of each product will be small. This complicates the surveillance program. Different sampling plans will have to be used for each product; the sampling and replacement-of-stocks schedules will be complicated because different foods deteriorate at different rates; and the amount of material removed at each sampling period may well be a sizeable proportion of each lot. These are potent arguments in favor of a simple diet consisting of only a few products.

There is another approach that could be made to the surveillance sampling program. Instead of taking the quantity of a product in a single shelter as a "lot", one could consider all of that product in all the shelters in one city, for example, as the lot. Then the stocks in only some of the shelters would be inspected. Such a system would not work well, though, if the product quality from shelter to shelter and the shelter conditions were not relatively uniform. If food stocks are obtained from diverse sources, some shelters could have a totally deteriorated stock while the average for the entire area is still satisfactory.

With any sampling system, the food supply must include the quantity that will be needed for samples to be taken during inspections over the entire anticipated storage life.

3. The average deterioration rate under various environmental conditions for each product. Adequate information on long-term shelf-life of most foods does not exist. Although there are many publications about the deterioration rates of foods, they do not apply specifically to shelter circumstances. Many studies have been done with an eye to the commercial market where storage life beyond 2 years is unimportant, hence, the studies have been ended before the results of long-term storage could be observed. ("Long-term" is used here to mean 5 to 10 years.) A large body of information on food stability has been

developed in connection with military requirements. Military combat rations are generally packed in more durable packages than those commonly used for domestic markets, and many of the products studied have been developed to meet highly specific military requirements which are not necessarily applicable to shelter rations. (Storage stability is discussed in Chapter 3.)

4. The expected variability in deterioration rate for each product. It is known that there is wide variability in the deterioration rates of some foods but the extent of this variability is practically never known. The variability may arise from many causes: differences in raw material, processing, packaging; and differences in the time and storage conditions to which the product may have been exposed before it was stockpiled. Foods purchased through commercial trade channels may already have expended a substantial part of their useful shelf life.

Many studies have been made on, for example, a single lot from a single packer, or a very limited number of such lots, or on special packs. From such studies no adequate estimate can be made of the variability in deterioration rate from lot to lot of commercially available foods. If foods from commercial markets are to be used for stocking shelters, some estimate of this variability will be needed to construct sampling and replacement programs. Of course, similar information would be needed on special packs, but it should be easier to get because fewer suppliers, would be involved.

5. The level of product quality required for useful service under emergency shelter conditions. The lower quality limits of acceptability, for shelter purposes, of various foods are not known; and correlation of acceptability level with objective measurements has not been investigated in terms of shelter requirements. (Quality criteria are discussed in the next section.)

6. The methods to be used to measure product quality and the precision of the measurements. For many foods, inexpensive objective methods have not been developed to measure the quality level of foods. (This subject is discussed in the next section.)

Quality Criteria and Test Methods

The selection of criteria for defining the end of storage life is difficult but of great practical importance. The problem usually is not one of obvious damage to food by microorganisms or insects, or gross package failure, but rather an elusive one of flavor, color, or texture change and, to a certain extent, a reduction in nutritive value. It must be stated emphatically that the "end of storage life," as used here, does not involve food safety or imply any specific health hazard.

What methods and standards are available for judging foods? Taste tests seem, at first glance, to be the logical approach. But they are not as simple as they seem. Taste testing, either by trained judges or a consumer panel, is a complicated business.

Deterioration of food products has sometimes been judged by the "first detectable difference." For shelf-life evaluations, this is the storage time elapsed before a panel of trained judges can detect (with statistical significance) a difference between samples held under two different storage conditions, one of which causes negligible deterioration. How these judgments correlate with consumer acceptance is usually not known. Therefore, the method of "first detectable difference" is too sensitive to be practical in the judging of foods for shelters, nor can it be used as an index to acceptability until the correlations between expert judgments and consumer acceptance are established.

In appraisals of products for Army rations, hedonic scales have sometimes been used with rejection standards of "like moderately well." For emergency conditions of shelter feeding, as low a standard as "moderately dislike" may be good enough.

The question here is: how high should standards be set for foods stocked in shelters? Many people are remarkably insensitive to off-flavors and odors. Under shelter conditions and with nothing for direct comparison, perhaps most people would fail to detect quite a lot of "deterioration." It is proposed here that standards required of foods to be sold competetively in commercial markets or to be used for feeding the military forces are higher than economically feasible as replacement levels for shelter foods.

Quality can be defined, of course, in terms other than "like" and "dislike," for example:

1. Changes in color, flavor, and odor.

2. Chemical changes as indicated by dissolved tin in canned products, vitamin level, optical density of extracted pigments, sulfur dioxide level, amount of free fatty acids, etc.

3. Texture changes, such as gelling, caking, curdling, separation of blended ingredients, dehydration, mushiness.

4. Loss of solubility, or failure of dried foods to rehydrate.

5. Package failure, such as can corrosion from the outside resulting in rust and ultimate leaking, internal can corrosion, hydrogen swells, collapsed cans, burst or leaking sacks and boxes, etc.

6. Damage from microorganisms--mold growth, fermentation, or bacterial spoilage.

7. Insect or rodent damage.

For any test that is used to judge quality, the point at which a food would be classed as unacceptable should be preselected. The objective chemical tests chosen should correlate with subjective evaluations of quality. In an instance where more than one test is applicable, one change may be more critical than another. For example, a serious change in flavor might occur long before any visible signs of deterioration can be detected. It is essential that the critical changes be known and the appropriate test used.

For each shelter in operation, the data collected at successive inspection periods will provide information on the rate at which each product is deteriorating. With rare and unimportant exceptions, shelter temperature and humidity will be the rate-determining factors. Rate data will forewarn the inspector of appropriate changes to be made in his surveillance sampling plan and schedule.

Inspection Staff and Costs of Surveillance

The caliber and number of individuals available to do inspections will influence the choice of methods used for judging the stage of deterioration in the shelter foods. Obviously a

complex chemical method would be inappropriate if inspections are conducted solely by local Civil Defense volunteers. Almost equally impractical are sensory tests (flavor, odor, color). On these, even trained judges differ widely in their judgments. Sensory tests might be useful in situations where the shelter is wholly controlled at the local level, that is, where both the responsibility for making the evaluation and the authority for replacing the degraded stocks are vested in one individual or a single group. Then, a simple decision as to whether or not the food should be thrown out and a new supply purchased could be made by the local control authority.

Centralized supervision of shelters, as by a state, the Federal government, or a large corporation, requires uniform standards for quality evaluation. Here chemical tests offer promise because of their relative objectivity. Most chemical tests, however, would have to be conducted by trained personnel with suitable laboratory facilities.

Many symptoms of food deterioration can be recognized by anyone with a small amount of training. Texture changes, for example, are obvious but they are pertinent to only a limited number of foodstuffs. Solubility, dispersibility, and completion of rehydration are easily tested and certainly would be used as part of an evaluation of dehydrated foods. Gross package failure is obvious, but inspectors would need some training to evaluate trends and recognize symptoms of beginning deterioration. Damage from microorganisms such as mold growth, swollen cans, or odor from spoilage, and insect and rodent damage are usually obvious.

At present no food inspection system exists that is directly applicable to maintenance of fallout shelter food stockpiles. However, the Agricultural Marketing Service of the United States Department of Agriculture conducts an inspection, sampling, and evaluation service for the certification of products as to Federal grade standards. By a modification of objectives and the use of appropriate test methods the system could be applied to shelter maintenance programs.

The charge for AMS inspection and sampling is $5 per hour with a minimum of $10 per lot. Individual analyses range from $2 to $20 each (50). On this basis, if 10 different food items were stocked in a shelter and if the stockpile were checked twice a year, the minimum cost of surveillance would be $200 per shelter per year. If more than one test were required for some products at each inspection, the cost would be even higher.

If the cost of periodic inspection exceeds the cost of food replacement after "safe" storage intervals, then replacement after a prescribed time interval is suggested. Of course, other factors enter, too: such as the availability of food for restocking the shelters, and the possible salvage value of stocks coming out of the shelters.

Present Capabilities and Suggested Research

With existing knowledge, it does not seem possible to guess with reasonable accuracy what the shelf life of shelter food supplies would be. This is because deterioration rates of the products are not well defined, the variability of deterioration rates amongst lots of the same products is not known, and the temperature and humidity level of storage space can not be predicted. These areas of ignorance, combined with a lack of information on quality evaluation and appropriate quality standards for shelter foods, prevent the immediate development and use of efficient surveillance sampling plans.

The only method currently available for surveillance of shelter food supplies involves guesswork and opinions. By extrapolation from existing knowledge of product shelf life, an arbitrary sampling schedule could be developed. Samples would be subjected to the opinion of a food evaluation panel that would determine whether a product should be replaced. Such a simple method could be costly in terms of evaluation procedure, risks of food waste, and risks of facing an ultimate food emergency. Furthermore, judgments might be made involving fiscal irresponsibility that would be very difficult to audit. Records of chemical analyses and physical measurements are more reliable.

A fallout shelter construction program that contemplates storage of food supplies for a sizeable part of the U.S. population could be a very costly undertaking. A haphazard program will be wasteful and risky. In order to broaden knowledge that is appropriate to shelter food stockpile planning, investigations are necessary on the following subjects:

1. Long term storage studies of foods under conditions typical of those to be found in shelters. Data on variability in deterioration rates and the effects of various packaging and other environmental factors are needed, as well as reliable test methods for measurement of storage-induced quality changes.

2. Psychological and sociological studies of the responses of people to food of various quality levels, including the effect of satiety on acceptance of foods.

3. A study of various surveillance sampling and food rotation systems, including costs.

Chapter 5. FOOD SERVICE IN SHELTERS

Management

Shelter food service should be well planned in order to keep initial investment in service equipment low, to minimize shelter space devoted to food preparation and serving, and to simplify procedures so that the inexperience of shelter managers and human blunders will have a minimal effect. However, unforeseen problems are almost certain to be encountered, so an extreme flexibility must be maintained in all operations planned. Simplification of the menu will generally lead to simplification of preparation and service.

Food service in shelters is concerned with heat for cooking or warming food, utensils and equipment, water supply and distribution, manpower use, heat and vapor disposal, waste disposal, procedures for equalizing or restricting issue of supplies to occupants, and traffic management within the shelter in connection with food distribution. The time, per se, that is required for food preparation may not be a critical factor. Usually, in problems of mass feeding, efficiency (or costs) is measured or influenced by time factors, but this is not necessarily true for the shelter situation. The time required for distribution of food may be important, but time devoted to food preparation might well spread over the greater part of the day. Related factors, like the amount of heat produced, would control the practices possible.

For purposes of discussion, three generally different food servicing arrangements may be considered possible for shelters:

1. Centralized kitchen service.

2. Food preparation by subgroupings of occupants.

3. Distribution of individual rations.

Centralized food preparation allows maximum control over the preparation and distribution of food and uses equipment and labor most efficiently. From a central kitchen the food could be distributed by bringing the people past a single distribution point or food could be carried to several different areas in the shelter. For multi-item rations with large packages of different components, centralization of food preparation may be the only feasible procedure.

However, there are problems connected with centralized food service. Supervision and management responsibility will be an additional burden to the shelter manager. He will bear the blame for

all functional errors including those of shelter design and food selection and service, as well as his own errors. On the other hand, centralized food service gives him a disciplinary tool. It also enables him to prevent waste and control food if rationing is necessary.

In crowded, overheated shelters with high humidity and with a limited water supply for housekeeping, an outbreak of food poisoning is a distinct possibility and could prove disastrous. A centralized food service increases the likelihood of widespread incidence of any such illness.

A single kitchen to serve a large group of people will require a rather complex organization, even at best. It can be handled efficiently only if a specialized crew is available or trained promptly. This procedure confines food service activity to the fewest number of shelter occupants, and that may not be desirable. A shelter population may be more satisfied and more easily managed if the members are usefully employed; food service is one of the few activities available.

In very large crowded shelters, the time element for food distribution from a single kitchen and the attendant traffic problems may become crucial factors. These problems have been studied and reported by Dunlap Associates (12) and Panero (37).

Food preparation by groups offers some favorable features. In this system food would be distributed to group leaders for preparation and consumption by sub-groupings of the shelter occupants. Groups of 10 to 100 people are suggested, but optimum group size has not been determined. In shelter habitability tests at Parks Air Force Base 100 men were fed and only extremely simple kitchen equipment was used (47).

Delegation of food handling activities to group leaders reduces the responsibility of the shelter manager to a supply function and allows him more time for his other responsibilities of welfare, communication, equipment maintenance, discipline, etc. At the same time, it encourages an early selection of leaders close enough to individual problems to provide continuing representation of individual interest to the shelter manager. As added benefits, it provides more of the occupants with something useful to do with their time, and it tends to confine any food spoilage outbreak to a relatively small group.

A disadvantage of the system amy be the slight increase in investment for equipment or utensils, such as hot plates, stock pots, or coffee urns.

The issue of individual rations for each day or for the entire shelter period would put the responsibility upon each individual for food preparation and clean up. This method would be useful only in situations where a very simple or austere ration is used. If the shelter is so crowded that movement is very restricted it may be the only feasible procedure.

The individual food issue tends to place food service outside the effective control of the shelter manager. If a single-ration package were used, it would complicate the problem of modifying quantities in case the food supply needed to be stretched out because of overcrowding or an extended pin-down period.

Another hazard is the possibility that individual food caches could contribute to gambling, stealing, hoarding of stale food, and other undesirable practices.

Heat for Cooking

A hot beverage or food is most desirable to relieve stress. If at all feasible, heat for cooking or warming food should be provided in shelters. A heat exchanger utilizing the exhaust of a gasoline or diesel motor used for emergency generation of electric power could provide hot water at no added fuel cost. If emergency equipment were not necessary, it is assumed that outside power would be available so that immersion heaters or hot plates could be used. A most economical service of hot food and beverages can be accomplished by use of hot water to reconstitute dehydrated products.

The selection of foods that need more than just hot water for preparation will require a means for disposing of heat and cooking by-products (fumes, smoke, steam). If the kitchen were located in the shelter and partitioned off from the shelter proper in such a fashion that the cooking fumes and heat could be exhausted through the same system that exhausts the shelter air, there would be no need to raise the temperature or humidity within the occupied part of the shelter.

If heating and exhaust facilities are available, unprocessed grains and legumes could make up a substantial part of the food stockpile. Rice and beans are inexpensive and, if protected from moisture, can be stored for very long periods of time without loss of food quality. Ingredients for a simple pan bread (flour, baking powder and salt) are also very stable and would be very inexpensive ration items. There is always the hazard, though, that the outside power might fail and the fuel supply for the emergency power system might be adequate only for intermittent operation; without cooking, the unprocessed foods would be nearly inedible.

Handling of the Water Supply

The food servicing facilities and handling techniques may be useful in the disbribution and control of the water supply. The method by which occupants receive a fair share of food (i.e., by measured cupful, bowl full or ladle full) might also be used to see that each has a fair share of water each day. Only when water is plentiful could its use be left in the hands of individuals.

The amount of water available in a shelter will directly affect the kind of menu that should be planned. If the supply is limited, the water must be used, of course, for drinking. Only if there is a surplus after this use can it be available for sanitation. The heating of large kettles of sticky food will require excessive dish washing. Likewise, re-usable dishes will require much water for washing, and will demand strict sanitation procedures to prevent spread of disease. The alternative is disposable dishes, and they contribute to the volume of trash that must be disposed of. The circumstances of the individual shelter must determine which system is used. In any shelter, the simple menu will simplify other problems.

In a recent shelter habitability test it was discovered that a problem in sanitation was created by the non-fat dry milk in the ration. This food has been widely recommended for shelter food stockpiles, but the shelter manager of this test said he would be greatly pleased if it were omitted. The kettles in which the milk was mixed were very difficult to clean, and the re-usable cups which the occupants used several times a day for coffee and the milk became messy and unhygienic. Each person washed his own cup at a water tap and the sump beneath the tap got sour from the milky wash water. In contrast, the cups used only for coffee were easy to keep clean.

If the water supply is less than generous, any water used for dishwashing should be saved for cleaning floors or flushing the toilets.

Waste Disposal

Waste food and water could be thrown into the toilets, provided these facilities have adequate capacity. With any feeding scheme such wastes should be kept to the minimum possible.

Solid wastes such as tin cans and disposable dishes pose a problem. Some shelter plans propose an incinerator for waste paper, but unless the burner is adequately shielded it will raise the shelter temperature. An alternate plan is to deposit all

solid wastes in covered drums or plastic bags. If food is stored in master containers, these could be used as waste receptacles as they are emptied of food. The plastic bag system was used at the shelter habitability test at Parks Air Force Base in December 1959. The bags were 2 feet in diameter by 6 feet high; two of them were filled each day in a 100-man shelter. During the test period, 50 of the men were on a diet of C-rations, which produce a large volume of small tin cans, and the other 50 men were living on powdered milk and dextrimaltose powder mixed with water and supplemented by peanut bars, which left a small volume of trash. After the fourth day the bags were thrown out of the shelter each day; this would probably be possible under fallout conditions. The system of storing trash in bags proved quite satisfactory.

Utensils

The kinds and amount of utensils required will depend upon the ration selection and food service decisions. Because of sanitation problems, disposable utensils should be used where possible and several small containers for serving should be preferred to one large one. In holding a large vat of warm food, spoilage organisms are given a chance to multiply. Normal delays in serving out of large vats could lead to food poisoning outbreaks.

In general, disposable dishes and utensils for individual use are recommended in the interest of hygiene and water conservation. Of course, if a shelter should have efficient dish-washing facilities, re-usable dishes would be cheaper and the waste disposal problem would be less. A re-usable cup for drinking between meals is suggested. The minimum amount of kitchen and serving equipment needed to serve meals that include some hot food is listed in Table 4.

TABLE 4. Utensils and kitchen equipment for a modest shelter ration

Hot plates or other heat source
Stock pots
Pitchers
Coffee urn
Ladles to measure portions
Can openers
Large spoons
Knives for opening packages
Dish-cleaning equipment
Individual disposable bowls
Individual disposable spoons
Re-usable cups
Trash containers

Food Rationing

A major objective of any food service is the distribution of equal portions to each occupant. (Some variation may be made on the basis of sex, age, and shelter activity. Thus, for young children portions might be smaller and for men engaged in some physical activity they might be larger.) Individual rations, individually wrapped, would provide maximum assurance of equal portioning. However, such may not be economically feasible nor managerially desirable. Individual packaging is expensive, and the opening of small packages (if in tin cans) would create problems such as need for can openers, danger of injury on sharp tin lids, etc.

In controlling the rate of use of food supplies the shelter manager has various possibilities. He can restrict portion size, or he can restrict the number of meals. If food and water shortages are serious, it has been suggested that no food or water be consumed for the first 24 hours to allow metabolic changes to occur that will tend to make more efficient the subsequent use of food and water (23). Such a recommendation flies in the face of the sociologist or psychologist who would provide reassurance to occupants by feeding them as soon as possible after entry into the shelter. This basic conflict between the physiologically and psychologically desirable cannot be compromised within the scope of this work. Its solution will, however, have a bearing on design and selection of food servicing arrangements in shelters.

Pre-occupancy training will probably not be developed to a degree that an organized food service will be functioning within a few hours of entry into a mass shelter. If there is a day's delay before feeding is started, that would allow the shelter manager ample time to organize his food service. But, if it is deemed necessary to provide an early feeding, the food or beverage should be in a form to be distributed with little or no preparation.

Suggested areas for research

1. Investigation of various food servicing arrangements by tests made in actual crowded conditions--evaluation of centralized vs. individual service, methods of portion control, handling of special diets for infants or invalids, design or selection of preparation and serving utensils, etc.

2. A study of the heat load produced by cooking and other problems associated with a diet based on unprocessed foods.

3. A study of hygiene, safety measures, and waste disposal.

Chapter 6. FOOD SELECTION

Food Preferences

The primary purpose of food is nourishment. In the case of food provisions in shelters, other reasons may equal in importance this direct food value. The shelter stay is estimated as two weeks and, in this period, most healthy people could survive with no food. But their health and vitality might suffer and, perhaps more important, their morale could be seriously damaged.

In a shelter, then the purpose of food is more than mere nourishment. The food must be palatable, or at least acceptable. In discussing foods for survival, Hutchinson (23) has said, "The need for a high degree of acceptability can hardly be over-emphasized. There is little to be gained by providing a ration that may be ideal scientifically but which survivors will not eat, or only in the last extreme. During periods of stress, many people prefer to go hungry rather than consume food that is unpalatable or with which they are not familiar. In the last extreme, they will eat almost anything but, by this time, there could be considerable impairment of bodily functions. A sudden emergency is not the time to introduce unfamiliar foods or untried novelties."

Finding foods that satisfy most tastes is no mean task, even when other factors that limit a food's suitability for shelter use are excluded. Regional differences, religious dicta, customs of national origin, all may influence food plans. But the extent of these influences will be limited because there is not, at present, a very wide variety of foods that are really suitable for shelter food stockpiles. To the extent that choices are available, local preferences should be met in stocking a shelter.

As mentioned in Chapter 1, special foods for infants, invalids, and the aged are considered as a medical problem and beyond the scope of this study.

The question of quality standards is discussed in Chapter 4, where it is treated as an integral part of the food surveillance problem.

Within a given shelter, the individual choice of foods (because of age, whim, or minor ailments of occupants) does not seem feasible or desirable. Foods may have to be strictly rationed if the shelter stay is prolonged; individual choice would complicate this problem. Unequal distribution could lead to fights.

In extreme cases, especially if the pin-down period is extended, individual food selection could result in dietary imbalance.

The foods selected should be suitable for very young children as well as adults, and all would receive the same items. The exceptions would be under medical supervision.

Nutrition

For a period as short as two weeks, survival or even good vigor does not depend upon an optimum balance of nutrients and a high calorie intake. Foods normally acceptable to U.S. residents, if provided in the amount of 2000 calories per day, will probably contain the minimum essential nutrients. Possible exceptions are vitamin C and thiamine shortage and amino acid imbalance. The vitamins could be included in the medical stockpile. The amino acid balance should be satisfactory if dried milk or some other protein-complete food supplies part of the protein in the diet.

High protein level, however, is contraindicated because water supply in many shelters may be limited. In case of restricted water availability, protein content of food should be kept at a fairly low level in order to minimize renal activity. The Quartermaster Food and Container Institute reports (56), "A food unit, in which seven to eight percent of the calories are derived from protein, could be consumed in any multiple number with maximum benefit from the protein at each energy level and without damage to the water economy." They further say, "Unless an ample supply of water can be absolutely assured the risks endangered by high protein seem unnecessarily great in proportion to the benefits."

The OCDM Interdepartmental ad hoc Advisory Group on Research and Development for Food for Shelters recommended, in May 1959, certain nutritional allowances for planning rations for shelters (Table 5). These allowances represent, also, the opinions of the Food and Nutrition Board, consultants to and staff members of the Interdepartmental Committee on Nutrition for National Defense, and representatives of the Department of Health, Education, and Welfare. The nutritional allowances recommended will provide at least the minimal requirements. The recommendations do not prescribe that the rations need to be this restricted.

In winter occupancy of shelters in northern areas, more food energy may be required to combat low temperature. This possibility should be considered although body heat in an overcrowded shelter may be sufficient to keep temperatures high.

TABLE 5

MINIMUM NUTRITIONAL ALLOWANCES

As consumed per capita per day 1/

	Survival		Austere	Near Normal
Weeks	2	4	8	8
Water, quarts	2	2	2	4 2/
Calories	1500	1500	1800	2000
Protein, gms.		35	50	65
Thiamine, mg.			0.4	0.6
Vitamin C, mg.			10	30
Niacin, mg.			5	8
Riboflavin, mg.			0.7	1.0
Calcium, gm.			0.3	0.4

1/ To meet physiological needs.

2/ Includes water for cooking and drinking.

Recommendations of the OCDM Interdepartmental ad hoc Advisory Group on Research and Development for Food for Shelters, May, 1959.

Ration Concepts

To recapitulate the criteria for selecting foods for shelters:

1. The food must be palatable, or at least acceptable, to the majority of the shelter population.

2. Foods selected should have good storage stability, preferably a shelf-life of 5 to 10 years.

3. Total cost (including capital investment, costs of surveillance during the period of food storage, and replacement costs of deteriorated food) should be kept to a minimum.

4. Foods selected should be widely available. If a food is not now on the market in quantity, any special production should be simple and cheap.

5. A relatively low protein level is desirable.

6. The foods should have high bulk density to conserve storage space.

7. Food preparation should require a minimum of fuel and produce a minimum of heat and vapor.

8. Simple food preparation and serving may be essential because of extremely crowded conditions in shelters.

9. The food and service should produce a minimum trash volume.

Very few foods score well under all of these tests. Canned fruits, vegetables, and juices are too bulky; meat, eggs, and dairy products are too high in protein; many cereal products require cooking in the shelter and many other cereal products are bulky; ready-to-eat mixtures are costly; and most foods have a relatively short storage life. The choice, then, will be a compromise.

Opinions about what constitutes an appropriate shelter menu vary widely. The authors of this report have considered many suggestions that have been made, and have evaluated the proposals in the light of the criteria listed above.

Various shelter rations have been proposed; they seem to fall into five classes. They could be described as:

1. Dinner-as-usual, all items available now from retail or wholesale outlets.

2. One-dish meals with a variety of dishes served during the two-week shelter stay, all items available now from retail or wholesale outlets.

3. Survival or emergency food packs, available in limited supply.

4. An austere ration (single item).

5. A specially designed shelter ration (called the "cereal-based ration" in the following discussion).

Food lists have been prepared for each of these classes (Tables 6 through 10) and the various rations are compared in Table 11. Each ration concept will be discussed in turn.

TABLE 6 Dinner-as-usual - Familiar foods with menu variety
Available from retail or wholesale outlets

Part 1. Menu and Food Values

Item	Amount served	Calories per item	Calories per day	Protein, gms per item	Protein, gms per day	Fat, gms per item	Fat, gms per day
Breakfast:							
1. Coffee 1/	2 cups	18	18	1	1	0	0
3. Milk, non-fat	1 cup	90	90	9	9	Tr.*	Tr.*
4. Sugar	2 tbs. 2/	100	100	0	0	0	0
5. Crackers	4	70	70	2	2	2	2
8. Jam 3/	1 tbs.	55	55	Tr.*	Tr.*	Tr.*	Tr.*
Serve one:							
6. Applesauce	1/2 cup	92	96	Tr.*	0	Tr.*	0
Beverage, fruit-flavored	1 cup	100 est.		-		-	
		Sub-totals	429		12		2
Lunch:							
1. Coffee	1 cup	9	9	Tr.*	Tr.*	0	0
3. Milk, non-fat	1 cup	90	90	9	9	Tr.*	Tr.*
5. Crackers	4	70	70	2	2	2	2
9. Peanut butter	1 tbs.	90	90	4	4	8	8
Serve one:							
11. Luncheon meat	3 oz.	243	179	13	19	20	10
12. Tuna	3 oz.	170		25		7	
13. Sardines in oil	3 oz.	182		22		9	
14. Salmon	3 oz.	122		17		5	
19. Rice, instant	1 cup	205	205	4	4	Tr.*	Tr.*
Serve one:							
21. Tomatoes	1/2 cup	23	50	1	2	Tr.*	Tr.*
22. Lima beans	1/2 cup	76		4		Tr.*	
Serve one:							
25. Peaches	1/2 cup	87	92	Tr.*	Tr.*	Tr.*	Tr.*
26. Pears	1/2 cup	87		Tr.*		Tr.*	
27. Apricots	1/2 cup	102		1		Tr.*	
		Sub-totals	785		40		20
Dinner:							
1. Coffee	2 cups	18	18	1	1	0	0
5. Crackers	4	70	70	2	2	2	2
10. Margarine	1 tbs.	100	100	Tr.*	Tr.*	11	11
Serve one:							
15. Corned beef	3 oz.	182	192	22	21	10	11
16. Chicken	3 oz.	170		25		7	
17. Turkey	3 oz.	228		17		17	
18. Roast Beef	3 oz.	188		21		11	
20. Potatoes, instant	1 cup	145	145	4	4	1	1
Serve one:							
23. Peas	1/2 cup	85	85	4	3	Tr.*	Tr.*
24. Corn	1/2 cup	85		2		Tr.*	
25-27. Fruit 4/			92		Tr.*		Tr.*
		Sub-totals	702		31		25
		Daily totals	1916		83		47
		Percent, on calorie basis			17		22

1/ Alternate: tea
2/ Full day's ration
3/ Grape, apricot, or peach
4/ See list given under "Lunch"
* Trace

TABLE 6 Dinner-as-usual

Part 2. Cost and Storage Data

Item	Package type	Storage life, years at 70°	14-day food supply for 100 people			
			Original cost	Surveillance Cost/year 1/	Total cost/year 2/	Storage space, cubic feet
[illegible]stant	glass	2 to 5	$56 3/	$10	$24	2.00
[illegible]nt	glass	2 to 5	23	10	16	0.60
3. Milk, [illegible] fat,dry	can	2 to 5	42	10	20	9.27
4. Sugar	carton	Indefinite	7	none	<1	2.23
5. Crackers, soda	can	2 to 3+	30	10	20	22.00
6. Applesauce	glass	2 to 5	21	10	15	5.46
7. Beverage base	glass	2 to 3	29	10	20	1.50
8. Jam	glass	2 to 5	18	10	15	1.97
9. Peanut butter	glass	3 to 4	20	10	15	1.53
10. Margarine	can	2 to 3	9	20	23	0.80
11. Luncheon meat	can	2 to 3	34	20	31	1.50
12. Tuna	can	4 to 8	50	10	20	2.84
13. Sardines in oil	can	1 to 8	37	10	22	2.20
14. Salmon	can	2 to 8	33	10	18	2.00
15. Corned beef	can	3 to 8	49	10	20	2.26
16. Chicken	can	2 to 8	53	10	28	1.59
17. Turkey	can	2 to 8	53	10	28	1.59
18. Roast beef	can	2 to 4	41	10	24	2.72
19. Rice, instant	carton	3	70	10	33	8.00
20. Potatoes, instant	can	2 to 5	46	10	25	4.15
21. Tomatoes	can	2 to 5	25	20	32	5.28
22. Lima beans	can	2 to 3	29	20	35	5.28
23. Peas	can	2 to 5	21	20	27	5.28
24. Corn	can	2 to 3	24	20	32	5.28
25. Peaches	can	2 to 3	34	20	37	7.54
26. Pears	can	2 to 3	34	20	37	6.78
27. Apricots	can	2 to 3	40	20	40	6.78
		Totals	928		658	118
			$0.66/man day			

1/ Estimated from average storage life and AMS inspection charges (see Chapter 4).

2/ Total cost equals original cost divided over estimated average storage life plus surveillance cost per year. Average storage life may differ from mid-point of range shown in column 3.

3/ Cost based on stocking half coffee and half tea.

TABLE 7 One-dish meals
Available from retail or wholesale channels

Part 1. Menu and Food Values

Item	Amount served	Calories per item	Calories per day	Protein, gms per item	Protein, gms per day	Fat, gms per item	Fat, gms per day
Breakfast:							
1. Coffee	1 cup	9	9	Tr.	Tr.	0	0
2. Sugar	1 tbs. 1/	50	50	0	0	0	0
3. Milk, non-fat	1 cup	90	90	9	9	Tr.	Tr.
4. Crackers, soda	2	35	35	1	1	1	1
5. Jam	1 tsp.	18	18	Tr.	Tr.	Tr.	Tr.
		Sub-totals	202		10		1
Lunch & Dinner:							
1. Coffee	2 cups	18	18	Tr.	Tr.	0	0
3. Milk, non-fat	1 cup	90	90	9	9	Tr.	Tr.
4. Crackers, soda	4	70	70	2	2	2	2
5. Jam	1 tsp.	18	18	Tr.	Tr.	Tr.	Tr.
Serve one each meal:							
6. Corn beef hash	20 oz.	800		77		34	
7. Chili con carne w/beans	23 oz.	805		54		35	
8. Beans, Boston style	21 oz.	798		38		11	
9. Macaroni & cheese	18 oz.	792		30		38	
10. Beef stew	36 oz.	792		56		36	
11. Chicken & noodles	38 oz.	798		41		38	
12. Chop suey	30 oz.	810	1600	39	87	30	61
13. Chop suey noodles	2 1/2 oz.						
14. Lamb stew	32 oz.	800		47		38	
15. Chicken & dumplings	35 oz.	805		24		47	
16. Beans & Franks	18 oz.	810		40		37	
17. Spaghetti w/meat or cheese	32 oz.	800		19		20	
18. Split pea soup	24 oz.	792		47		17	
19. Minestrone	33 oz.	792		30		24	
20. Beef goulash	35 oz.	805		69		25	
	Daily totals		1998		108		62
		Percent, on calorie basis			22		28

1/ Full day's ration.

TABLE 7

One-dish meals

Part 2. Cost and Storage Data

Item	Package type	Storage life, years at 70°	14-day food supply for 100 people: Original cost	Surveillance cost/year 1/	Total cost/year 2/	Storage space, cubic feet
1. Coffee, instant	Glass	2 to 5	$68	$10	$27	2.19
2. Sugar	Carton	Indefinite	4	None	<1	1.12
3. Milk, N.F. dry	can	2 to 5	42	10	20	9.27
4. Crackers, soda	can	2 to 3+	15	10	15	11.00
5. Jam	glass	2 to 5	12	10	13	1.36
6. Corn beef hash	can	2 to 4	87	10	39	8.28
7. Chili con carne w/beans	can	2 to 5	85	10	38	8.28
8. Beans, Boston style	can	2 to 3	37	20	32	7.35
9. Macaroni & cheese	can	no data	38	20	33	7.35
10. Beef stew	can	2 to 4	124	10	51	13.00
11. Chicken & noodles	can	2 to 4	156	10	62	13.93
12. Chop suey	can	2 to 3	109	20	56	9.94
13. Chop suey noodles	can	no data	46	10	25	10.60
14. Lamb stew	can	2 to 4	112	10	47	11.87
15. Chicken & dumplings	can	2 to 4	140	10	57	12.62
16. Beans & Franks	can	1 to 4	72	10	34	6.22
17. Spaghetti w/meat or cheese	can	2 to 5	81	10	37	11.07
18. Split pea soup	can	2 to 3+	48	20	36	8.85
19. Minestrone	can	2 to 3+	47	20	36	12.62
20. Beef goulash	can	2 to 4	120	10	50	12.62
		Totals	$ 1443 $ 1.03/man day		$ 709	180 cu. ft.

1/ Estimated from average storage life and AMS inspection charges (see Chapter 4).

2/ Total cost equals original cost divided over estimated average storage life plus surveillance cost per year. Average storage life may differ from mid-point of range shown in column 3.

TABLE 8

Survival and Emergency Packs

Available in limited supply

Company Code	Item	Calories per day	Protein %	Storage life years at 70°	Cost per man day	14-day supply, 100 people: Cost 1/ per year	14-day supply, 100 people: Storage space, cubic feet	Comment
	Military Operational Rations:							
	QMC all-purpose Survival ration	1740	7	3	$2.00	$ 953	126	No cooking required. 1740 calories=2 rations.
	"C" type ration	2200	High 2/	2	1.62	1154	183	No cooking. Many small cans to dispose of.
	5-in-1 ration	3600	"	1 to 1-1/2	1.83	2582	350	Requires cooking. Many small cans.
B.	5-in-1, commercial pack	3600	"	1	3.95	5550	350	Requires cooking. Many small cans.
B.	Coast Guard ration, commercial pack	375	no data	1	0.75	1070	58	Coast Guard considers this ration as absolute minimum for 8 days. Pack includes water.
C.	Coast Guard ration, commercial pack	450 est.	"	5	0.94	273	58	
	Forest Service emergency ration	2000 est.	High	2	1.70	1210	177	No cooking.
B.	Basic survival	1000	High	1	1.95	2750	no data	No cooking. Includes water.
B.	Air Force food packet, commercial pack	1700	Low	1	2.30	3220	36	No cooking.
A.	Survival ration	2011	8	5	1.09	315	36	No cooking.
D.	Camp food pack	3 full meals	High	no data	1.25	875	no data	Dehydrated food in foil packets; also available in bulk. Requires cooking.
E.	Emergency food pack	2300	16	5	1.95	556	122	Requires cooking.
F.	Survival kit	3 full meals	High	no data	0.57	419	50	Cooking desirable but not essential.
G.	Disaster food kit	1800	46	1-1/2	1.28	1215	53	Liquid diet.

1/ Includes estimated surveillance cost.

2/ "High" means balanced proportion of components for general use.

TABLE 9

Austere Diets

Expanded production or some developmental work needed

Item	Calories per day	Protein %	Storage life, years at 70°	Cost per man day	14-day supply, 100 people: Cost 1/ per year	14-day supply, 100 people: Storage space, cubic feet	Comment
Borsook's formula 2/	570	50	5+	$0.17	$57	23	6 oz/day
Peanuts	2035	19	2	0.42	314	16	13 oz/day
Monkey chow 3/	2000	18	2	0.12	104	27	21 oz/day
Supplemented dried milk 4/	2000	24	2 to 5	0.36	156	36	Liquid diet.
Commercial survival biscuits (H) 5/	2000	8	no data	no data	---	55	17 oz/day
WU cereal wafer	2000	6	5 est.	0.24	77	36	17 oz/day

1/ Includes estimated surveillance cost.
2/ A formulated meal based on soy protein.
3/ A ration mixture based on corn, wheat, oat groats, soy beans, milk and molasses, with vitamin and mineral fortification. May have salvage value as feed.
4/ A mixture of non-fat dry milk, dextrimaltose, and vegetable oil.
5/ Code letter to identify company.

TABLE 10

Cereal-based ration

A special ration for shelter food stockpiles; not available at present

Part 1. Menu and Food Values

Item	Amount served	Calories per item	Calories per day	Protein, gms per item	Protein, gms per day	Fat, gms per item	Fat, gms per day
Breakfast:							
1. Coffee	1 cup	9	9	Tr.	Tr.	0	0
2. Milk, non-fat	1 cup	90	90	9	9	Tr.	Tr.
3. Sugar 1/	2 tbs.	100	100	0	0	0	0
4. Cereal wafers	4 (80 gms.)	336	336	5	5	2	2
5. Jam	1 tbs.	55	55	Tr.	Tr.	Tr.	Tr.
6. Raisins	1-1/4 oz.	95	95	1	1	Tr.	Tr.
		Sub-totals	685		15		2
Lunch							
1. Coffee	1 cup	9	9	Tr.	Tr.	0	0
2. Milk	1 cup	90	90	9	9	Tr.	Tr.
7. Cocoa beverage pwd.	1 tbs.	70	70	1	1	2	2
4. Cereal wafers	4	336	336	5	5	2	2
5. Jam	1 tbs.	55	55	Tr.	Tr.	Tr.	Tr.
8. Peanut butter	1 tbs.	92	92	4	4	8	8
Serve one:							
9. Beef bouillon	1/3 cup	1		Tr.		Tr.	
10. Chicken bouillon	1/3 cup	1	1	Tr.	Tr.	Tr.	Tr.
11. Onion soup	1/3 cup	1		Tr.		Tr.	
Serve one: 2/							
12. Chili powder	1/3 tsp.	-		-		-	
13. Curry powder	1/3 tsp.	-	9	-	1	-	1
14. Cheddar cheese food, dry	1 tbs.	28		2		2	
		Sub-totals	662		20		13
Dinner:							
1. Coffee	1 cup	9	9	Tr.	Tr.	0	0
4. Cereal wafers	4	336	336	5	5	2	2
5. Jam	1 tbs.	55	55	Tr.	Tr.	Tr.	Tr.
8. Peanut butter	1 tbs.	92	92	4	4	8	8
Serve one: 3/							
15. Spaghetti sauce	1/3 cup	24		1		1	
16. Vegetable soup	1/3 cup	24	23	1	1	1	1
17. Mushroom sauce	1/3 cup	22		1		1	
18. Hard candy	1 oz.	110	110	0	0	0	0
		Sub-totals	625		10		11
		Daily totals	1972		45		26
		Percent, on calorie basis			9		12

1/ Full day's ration.

2/ Combine this seasoning with bouillon as topping for crumbled wafers.

3/ Sauce serves as topping for crumbled wafers.

TABLE 10

Cereal-based Ration

Part 2. Cost and Storage Data

Item	Package type	Storage life, years at 70°	14-day food supply for 100 people			
			Original cost	Surveillance cost/year 1/	Total Cost/year 2/	Storage space, cubic feet
1. Coffee, instant	glass	2 to 5	$ 68	$10	$27	2 19
2. Milk, non-fat, dry	can	2 to 5	42	10	20	9.27
3. Sugar	carton	Indef.	7	none	<1	2.23
4. Cereal wafers	5-gal. cans	5 est.	168	10	44	18.00
5. Jam	glass	2 to 5	54	10	24	5.69
6. Raisins	carton	>2	47	10	33	3.00
7. Cocoa beverage pwd.	can	2 to 3	8	10	13	0.90
8. Peanut butter	glass	3 to 4	40	10	20	3.06
9. Beef bouillon pwd.	glass	2	2	10	11	
10. Chicken bouillon pwd.	glass	2	2	10	11	0.20
11. Onion soup base	glass	2	2	10	11	
12. Chili seasoning	glass	2+	3	10	12	0.12
13. Curry powder	glass	2+	2	10	11	
14. Cheddar cheese food, dry	can	Indef.	5	none	<1	0.20
15. Spaghetti sauce, dry	can	2 est.	11	10	16	
16. Vegetable soup, dry	can	1	6	10	16	0.50
17. Mushroom soup, dry	can	2 est.	8	10	14	
18. Hard candy	can	3	41	10	24	3.40
		Totals	516		309	49
			$0.37/man day			

1/ Estimated from average storage life and AMS inspection charges (see Chapter 4).

2/ Total cost equals original cost divided over estimated average storage life plus surveillance cost per year. Average storage life may differ from mid-point of range shown in column 3.

Note: Inadequate storage data on dried foods (Items 9 to 17). Probably these foods would remain useful much longer than indicated.

TABLE 11 Comparison of several ration concepts for shelter food stockpiles

Item	Calories per day	Protein %	Fat gms/day	Cost per man day	14-day supply for 100 people: Cost 1/ per year	14-day supply for 100 people: Storage space, cubic feet
Dinner-as-usual	1916	17	22	$0.66	$658	118
One-dish meals	1998	22	28	1.03	709	180
Cereal-based ration	1972	9	12	0.37	309	49
"J" ration	2200	High	no data	1.62	1154	183
5-in-1 ration	3600	High	no data	1.83	2582	350
QMC all-purpose survival ration	1740	7	52	2.00	953	126
Commercial survival ration (A)2/	2011	8	42	1.09	315	36
Commercial survival kit 3/ (F)	3 full meals	High	no data	0.57	419	50
Boorsook's formula	570	50	low	0.17	57	23
Peanuts	2000	19	174	0.42	314	16
Monkey chow	2000	18	35	0.12	104	27
Supplemented dried milk	2000	24	52	0.36	156	36
WU cereal wafer	2000	6	56	0.24	77	36

1/ Includes surveillance cost.

2/ Code letter to identify company.

3/ Includes Borsook's formula.

The "Dinner as-usual" menu is an attempt to provide a feeding program that is as nearly normal or average as possible, and to accomplish this by obtaining the foods directly from the regular retail or wholesale channels. These foods are available now and in quantity. Several menus of this type have been recommended by Dr. Donald K. Tressler of the OCDM Interdepartmental ad hoc Advisory Group for use by the American Institute for Research in shelter habitability tests conducted in 1960. This ration concept is similar, also, to the reserve food supply for home shelters recommended in the OCDM Advisory Bulletin, No. 234.

The foods listed in Table 6 are an example or illustration of the dinner-as-usual ration concept; the list is by no means exclusive. These foods were chosen, however, because of their wide acceptability and availability and, when there was a choice, because of greater storage stability. Data on storage stability are from Woodroof's report (61), the NATO report by the Scientific Working Group on Long-Term Food Storage (32), technical manuals of the Quartermaster (52), and occasionally from unpublished sources. Costs are based on wholesale prices as of 1960; they were obtained from large grocery firms in the San Francisco Bay area.

The greatest advantage of the dinner-as-usual ration is, of course, the availability of the foods. The wide acceptability of the foods and the possible variation of the menu are favorable aspects. In addition, the food is nutritionally adequate.

The disadvantages, however, are very great. The total cost of acquiring and maintaining this type of food stockpile is high. To the original investment must be added the recurring costs of food replacement every two or three years as the food deteriorates and the even more frequent costs of food surveillance (see Chapter 4). Some of the foods in this ration have very poor storage life, from the viewpoint of shelter stocking. (See the discussion of current canning practices in Chapter 3.) The total cost of this dinner-as-usual 2-week food supply and its maintenance is estimated at $6.60 per man per year throughout the period of a fallout shelter program.

A second disadvantage is the complicated food service required. A full complement of plates, bowls, cups, forks, knives, and spoons is needed and each meal would produce a great volume of empty tin cans. Distribution of so many items (food and utensils) at each meal would pose a problem (see discussion of service schemes in Chapter 5). The nature of these foods, some of them wet and sloppy, would contribute to the monumental task of keeping the shelter tidy. Although most of the foods can be eaten cold, the rice and potatoes and perhaps the vegetables would require some cooking or at least heating.

The storage space needed for a two-week supply of food (not including utensils and other equipment) amounts to about 1.2 cubic feet per man; this figure is based on No. 10 cans which would require some kind of centralized food service. Individually packed portions would require much more room, and produce an even greater volume of empties.

Nutritionally the diet is adequate, even for long-term use; but in the event of a water shortage the protein level may be too high. If rationing is necessary or if personal preferences are indulged, it is possible that dietary imbalances could result.

In summary, this scheme for feeding shelter occupants should be avoided if at all possible.

A "one-dish meal" ration has been proposed by Dunlap Associates (12). They suggest a light breakfast of crackers, jam, and beverage and two hot meals consisting of canned meat-vegetable-cereal combinations, the one item containing all components of the meal. Table 7 lists 14 such meals. The list is not exclusive, but the combinations have been selected to reflect the more popular tastes, also to avoid items of known low storage stability, and to obtain high caloric density if possible.

The one-dish meal concept avoids some of the drawbacks found in the dinner-as-usual ration. Particularly it simplifies food service, especially if it is packed in individual servings as suggested by Dunlap Associates. But this introduces another problem--special packaging. These one-dish meals, even when packed in ordinary No. 10 cans, are much more costly than the dinner-as-usual foods (figures in Table 7 are based on No. 10 cans). If one-dish meals were packed in individual, key-opening cans, as suggested by Dunlap, they would be even more costly. In addition, the key-opening feature introduces a point of weakness as far as the storage life of the can is concerned.

By far the most undesirable feature of the one-dish meals is their surprisingly low caloric content. In order to get the 800 calories per meal that would bring the daily intake to 2000 calories, a serving of 1 to 2 1/2 pounds would be required. Eating such a quantity at one meal is obviously impossible for many people.

Admittedly, it is difficult to estimate the caloric content of mixtures that vary with the manufacturer. For example, U.S. Department of Agriculture publications give a caloric content for macaroni and cheese that is more than twice as high as that given by one of the manufacturers of this commodity. In general, data given by the manufacturers have been used to arrive at the figures shown in Table 7, because this feeding plan has been proposed as one that could be supplied from normal retail or wholesale outlets. Of course, special formulations with higher caloric density would be possible, but only at increased cost.

Aside from simplified food service and less chance of diet imbalance due to a possible sub-division of the ration, the one-dish meal scheme has nothing to recommend it over the dinner-as-usual plan. And it has some almost insurmountable defects. Estimated cost of stocking and maintaining this ration exceeds the cost of the dinner-as-usual ration (Table 11). As regular commercial items, these foods would have to be eaten in impossible quantities to supply the prescribed number of calories; as specially formulated and packed items they would be costly to produce, and practically nothing is known about their long-term storage stability.

Survival and emergency food packs are being marketed by a dozen or more companies. (Data on several packs are given in Table 8.) These packs range from the very austere to quite elaborate: some are commercial packs of military operational rations, some are collections of various dehydrated foods, some are concentrated foods designed especially as emergency rations. Most of them contain some items in addition to the food, such as personal comfort items, vitamins, cooking utensils or dishes, canned water, or emergency heat source.

A storage life of 5 years is claimed for some of these food packs, but no reliable data are presented by the packers. Note in Table 8 that Company B claims a storage life of 1 year for Coast Guard rations while Company C claims 5 years for the identical pack.

Military operational rations have been suggested for stockpiling in shelters. Data on three types appear in Table 8. These rations as well as the commercial packs, are, in general, more costly and no more stable than ordinary commercial products, and most of them are too high in protein. Two of the commercial food kits that seem to be possible candidates for provisioning shelters (they are identified as Company A's survival ration and Company F's survival kit) are listed in the summary (Table 11) for comparison with other food schemes.

It would seem that food packs, as a class, could be of greatest use by serving as a food stock in automobiles in case of evacuation of an area, or in any situation where the food supply must be carried by an individual from one place to another.

A strictly austere shelter ration has much to recommend it. Several such rations are listed in Table 9.

Dr. G. F. Combs of the University of Maryland, Dr. A. E. Shaefer of the U.S. Department of Health, Education and Welfare and Dr. John Browe, Department of Health, State of New York, among others, have suggested that a palatable, nutritionally adequate biscuit

constitute the sole shelter food. An existing biscuit approximating this description is the chow fed to experimental monkeys. Two commercial cereal processors are working on a more sophisticated version of the same thing. A cereal wafer under development at this Laboratory (Western Utilization Research and Development Division) could serve the same general purpose, although no attempt is being made to produce a product that is nutritionally adequate. For a limited shelter stay, optimal nutritional balance does not appear necessary. To formulate for nutritional adequacy would increase initial cost of the product and could reduce stability which would increase replacement costs. These specially compounded biscuits can be low in cost and entirely adequate to keep a population nourished. The only questionable aspect is concerned with the need to provide a ration that "sustains morale."

Other rations advanced as austere-type diets are peanuts or peanut candy bars; a high-protein formula developed in 1945 by Henry Borsook at California Institute of Technology; and a liquid food consisting of non-fat dried milk, dextrimaltose and vegetable oil.

Peanuts are more costly than the cereal biscuits and they may cause some intestinal distress. In a recent shelter habitability test (47) the peanut bars caused toothaches and sore gums. For a healthy, adult population peanuts might prove satisfactory but in the absence of conspicuous storage stability or other outstanding feature they seem to offer little promise.

The Borsook formula was designed as a food supplement to augment the low protein diets of underprivileged peoples--it was never intended to serve as the sole food (1). It has been suggested that sugar or a cereal food be combined with the formula to make a shelter ration. But even if the recommended day's ration of this formula (570 calories) were combined with a straight carbohydrate food to make a total of 2000 calories, the protein content of the diet would be too high for use in shelters if the low-protein regime is desired. The Borsook formula is 50% protein.

The milk-dextrimaltose-oil mixture was tried in a shelter habitability test at Parks Air Force Base in December 1959. It was not well liked (17,47). Its greatest virtue is its suitability for feeding infants.

Several of the austere diets are listed in the summary (Table 11) for comparison of costs and storage space required.

A <u>cereal-based ration</u> has been developed at this Laboratory and tested in two shelter habitability tests. The research work on a cereal wafer and evaluation of the cereal-based ration are the subjects of Chapter 7.

The limitation in protein content and palatability factors considered in the provisioning of shelters point toward rations with a high carbohydrate level. Historically, cereals have formed the backbone of austere, energy-producing diets in the parts of the world which produced the ethnic ancestry of this nation's people. And it is to cereals one turns when considering an abundant, low-cost raw material source in this nation.

Were cooking facilities possible, a daily loaf of fresh bread would almost certainly be considered an ideal survival ration for a week or two. However, a preserved cereal product that is a substitute for fresh bread is not known. Canned bread is a technological possibility that has a usefulness in military rationing. However, it is costly and does not have the long shelf-life desirable for shelter stockpiles. Furthermore, unless it can be heated, its palatability is considerably less than that of fresh bread. Hard tack is, likewise, a rather poor substitute for fresh bread and probably would not be palatable enough for a two-week shelter existence.

The specially formulated cracker or wafer (called WU cereal wafer) consists principally of wheat. It has a number of menu possibilities, thus some of its lack in palatability (as compared to fresh bread) may be compensated for by serving it in a variety of ways and in conjunction with a few foods or flavorings of moderate cost (Table 10). The basic product can be eaten out-of-hand and constitutes an austere-type ration by itself if necessary. It can be spread with jam, peanut butter, jelly, etc.; be crumbled and served with sugar and hot or cold milk as a breakfast food; be crumbled and served with a hot soup, sauce, or gravy, as a pilaf-type main course for lunch or dinner; and be combined with a sweetened fruit or syrup topping as a dessert. By these many uses, a single ration item--the cereal wafer--can be the major component of a shelter food supply. It can supply fifty percent or more of the food requirements, thereby reducing procurement and surveillance activities.

In contrast to other rations discussed, the cereal wafer part of this ration is not available at the present time. The spreads and toppings, however, are taken from available commercial supplies. It should be indicated here, that many of the toppings could be improved so as to reduce their initial cost, enhance their palatability for use with the wheat wafer, and increase their stability substantially.

Preliminary investigations on the ration concept have been concluded and a prototype wheat wafer has been developed and evaluated. Further developmental work on process and product formulation is required. At this time, five year's storage is indicated

as a possibility for the wheat wafer. With optimum process and formulation and adequate packaging, a 10-year or greater shelf life should be possible.

Although extensive product developments are needed for the cereal-based ration, we believe it to be the best one for an ultimate shelter system.

Chapter 7. A SPECIAL SHELTER RATION

Part 1. Development of a wheat wafer

Choice of Materials and Methods

Cereals offer certain unique advantages as the basis for a shelter ration. They are perhaps the lowest cost, most abundant raw material available; additionally, they are regularly present in some form in the daily diet of most of the U.S. population regardless of ethnic origins, religious beliefs, or diet habits. Wheat, since it enjoys the widest acceptance in Americans diets, appears to be the logical choice as a starting material. However, the other common cereal grains -- rice, oats, corn, barley, and rye -- would probably lend themselves to the same end if desirable.

Cereals appear in diets in many forms; baked products such as bread, crackers, and cookies; paste products such as spaghetti and noodles; in whole grain form such as rice, bulgur, and pearled barley; flakes or granules such as rolled oats and wheat, farina, and corn meal; and precooked dry doughs, namely the numerous ready-to-eat breakfast cereals. All of these familiar forms, because of their low bulk density, fragility, short storage life, a need for cooking, or other reasons, appear to be unsuitable as all-purpose shelter rations.

An approach to the problem of developing a cereal food for shelter stockpiling was suggested by a characteristic of parboiled rice noted several years ago (40). Parboiled rice (8 to 12% moisture content) expands several fold in volume when exposed for periods of a few seconds to air blasts at temperatures of 250° to 300° C. The resultant product is fully cooked, has a crisp friable structure and, because of the numerous small voids created by the expansion process, readily absorbs either hot or cold liquids. Bulgur (20) which is a pregelatinized or parboiled wheat, can also be expanded to give a similar product. Limited experiments indicate other pregelatinized grains react in like manner. The expanded bulgur is firm enough to withstand rigorous handling without breaking or crumbling and, in fact, can be ground and compressed without losing its desirable characteristics.

Pregelantinized grains have already undergone some processing involving major energy expenditures; as raw materials their cost is well above that of raw grains. Accordingly, some effort was expended on development of simpler and cheaper processes that would achieve the same ends. Two processes to date

have shown enough promise to justify further investigation. These are the hot-air treatment of moisture-conditioned wheat, and steam treatment followed by hot-air treatment of moisture conditioned wheat. Both techniques yielded products with some of the physical characteristics required and with a smaller energy demand than that required for expansion of dry parboiled wheat.

Compression and binding.

Pelleting is an economical and familiar commercial process for compressing bulk materials. Experimental pellets were made from ground expanded bulgur and evaluated for their usefulness. Their lack of flexibility in menu uses, and their unfamiliar form as a human food militated against this method of compression. In fact, the pellet form might actually cause complete rejection of a food because pellets are so frequently associated with animal feeds or pest control poisons. Compression into a more familiar wafer shape and size appears to be most desirable.

In order to form wafers firm enough to withstand handling, but friable enough for easy chewing and crumbling, some binding material had to be used. Water is an effective binder, but organoleptic and stability requirements dictate moistures of 4 to 5 percent in the finished product. Attempts to dry wafers to such a low moisture level resulted in either flaking or a rock-like hardness. The choice of a binder was markedly limited because it was necessary to use an essentially dry material and one that is acceptable under Food and Drug laws. Fatty materials were found to be most satisfactory because of their plastic flow characteristics over a wide range of temperature-pressure conditions. Materials investigated ranged from liquids to high melting point solids and included natural animal and vegetable fats, hydrogenated fats, fatty acids, and fatty acid monoglycerides. Fatty materials have the added advantage of markedly increasing the caloric density of the product.

The higher the melting point of the fat the better are its binding characteristics. However, fats with melting points well above body temperature are reported to be poorly absorbed in the digestive tract. Therefore, fats with melting points above 120°F. were avoided. Because emulsification is a factor in fat digestion, use of a surface-active agent might offer some advantage. No investigation of this possibility was carried out.

Some sugars (of low sweetening power) such as lactose and maltose and sugar-containing materials such as malt extracts or malt flours are also effective binders, though over a much narrower range of conditions. They also increase caloric density but to a lesser degree than would fats.

Formulation

Many possibilities exist for varied formulation of the wafer. Numerous flavoring materials, such as cheese, fruit, or bacon bits, could be added to form an assortment of snack-type products. Complete meals requiring only the addition of water could be made by incorporating powdered milk and sugar or various combinations of spices, herbs, and dehydrated vegetables and meat. Such an approach, however, would add serious complications to the already complex picture of product stability, procurement and standardization, and surveillance sampling procedures and costs.

The more desirable approach appears to be formulation of wafers of pleasantly bland flavor, palatable enough to be eaten plain yet neutral enough in flavor to blend well with a wide variety of possible flavor adjuncts. This tends to simplify many of the problems just mentioned and, additionally, allows wider flexibility in adapting to individual or group preferences.

Technological details

The material used to prepare cereal wafers was commercial bulgur made from California-grown soft white wheat. Bulgur processing consists essentially of raising the moisture content of whole wheat to at least 40 percent, gelatinizing the starch completely by steaming under pressure (usually 20 psi. or higher), drying the product to approximately 10 percent moisture, and milling slightly to remove a portion of the bran (20). Crude fiber content is normally in the range of 1-1/2 to 2 percent. This could be lowered by harder milling at this stage of production. Finally, the grain is cracked and screened into various grades of coarseness.

For making the cereal wafer, either cracked or whole kernels can be expanded with equal facility. Moisture content prior to expanding was in the range of 9 to 11 percent; optimum conditions, however, have not been accurately determined. Expanding was done by passing the grain on a moving belt through a stream of hot air at 265° C.; the air velocity was sufficient to keep the particles bouncing slightly on the belt. Residence time in the air stream was 20 seconds, though this could be varied somewhat to alter the amount of toasting given the grain. The grains should come off the puffer at approximately 2-1/2 to 3 percent moisture.

Equipment for continuous expanding of bulgur consists essentially of a moving continuous woven wire belt on which the grain travels through the air stream. The belt is powered by a variable speed drive so that residence time of the grain in the air stream can be varied from 10 to 120 seconds. Air is delivered by a

squirrel-cage blower from the bottom through the two layers of belt which act as baffles to distribute the air uniformly. Air velocity is variable from essentially 0 to 900 feet per minute, controlled by a damper on the intake side of the blower. Heat is supplied to the air by a gas burner positioned near the intake side of the blower and temperature is controlled by modulating gas flow to the burner through automatic controls. The whole equipment is enclosed in an insulated box and the amount of recirculation of heated air can be controlled between approximately 0 and 85 percent by means of an adjustable opening on the box near the burner.

After expanding, the grain was coarsely ground (or it could be left whole). Then it was placed in the heated bowl of a planetary-type mixer equipped with a wire whip or paddle and the other ingredients uniformly blended in. The formulation (at the current stage of development) is 79.5 percent bulgur, 10 percent fat (hydrogenated peanut oil, melting point 116° - 118° F., iodine value 50), 10 percent dry malt extract, and 0.5 percent salt. Fat was added in a liquid state and bowl temperature maintained high enough to retain the liquid state. The malt and salt were added after dissolving them in sufficient hot water to raise bulgur moisture content to 4 to 5 percent. Mixing continued for 20 minutes to allow uniform distribution and adsorption of the additives. Any further additives such as anti-oxidants or flavoring could be added at this stage.

Textural adjustments can be made by further grinding after the materials are blended. The degree to which the material is ground alters wafer characteristics markedly. If no grinding is used, higher pressures are required to form wafers of sufficient strength; the wafers are harder to chew and the material absorbs liquids very slowly. As the proportion of fines are increased due to grinding, lower pressures are required to form wafers, crunchiness of the wafers diminishes, and the rate of absorption of liquid increases. A wide range of particle sizes, obtained by grinding after incorporation of all additives, appears most desirable. Binding is improved, a measure of crispness is retained, and liquid adjuncts are quickly immobilized because the fines absorb the liquid rapidly, yet the product is rice-like in texture.

Wafers were pressed at pressures over a range of 7500 to 10,000 psi. and at temperatures from 40° to 70° C., with residence time of approximately 2 minutes. In commercial production, residence time could probably be reduced to a few seconds by feeding preheated material to the press. These conditions will vary with formulation, melting point of fat, and moisture content. If fat alone is used as a binder the determining factor is its melting point, whereas if malt is added moisture content also must be considered.

Each wafer contained 20 grams of material. No effort was made to determine the optimum size and shape for the wafers. They were pressed to approximately 1/3 inch thick and either 2x2 inches square or circular with 2.25-inch diameter; these are sizes and shapes common in commercially produced crackers and cookies. The circular wafers have better handling characteristics, i.e. less tendency for edges to crumble; square wafers could be packaged better and would require less cubage for storage of a given weight.

The conditions and formulations described above were based on subjective evaluations; time did not permit development or use of objective measurements related to flavor preference, wafer strength, or crumbling and chewing characteristics. A light toasting was given the grain during the expansion process to enhance the flavor. Both fat and malt were used because the combination gave desirable flavor and binding qualities. The use of both may also contribute to storage stability (see next section). Salt was added for the usual organoleptic reasons.

Storage stability

As with other cereal products, storage stability of the cereal wafers will depend on several factors. Undesirable changes over long periods of time can be minimized by proper formulation, control of moisture, use of antioxidants, proper packaging, and inert storage atmosphere. Adequate study of the effect of these variables has not been possible as yet.

Of the changes leading to deterioration, oxidative changes in the lipid fraction are most likely to occur first. Wheat contains approximately 2 percent of a highly unsaturated natural fat markedly susceptible to oxidative rancidity. Removal of this fat before or during processing offers perhaps the best possibility of eliminating or minimizing the problem. By treatment of the raw grain with dilute alkali combined with wet scouring to remove all or most of the germ, approximately 50 percent of this troublesome fat was removed.

A storage study of canned dry puffed bulgur was conducted to evaluate the effects of six different formulations, nitrogen compared with air as the package atmosphere, and three levels of storage temperature. The observations were made after the material had been stored for 47 days. This test indicated that a formulation containing both malt and fat may delay development of rancid odors. Rancidity was detected in most samples formulated with either malt or fat alone. But even after storage at 110° F., no rancid odor could be detected in any of the samples formulated with both malt and fat whether they contained antioxidant or not.

The test has not proceeded long enough to reveal any added protection that antioxidants might give. The inert storage atmosphere tended to maintain product stability.

Suggested areas for research

1. Studies of product stability and methods to extend it, including methods for defatting wheat.

2. Development of objective measurements of wafer characteristics and, based on them, refinement of procedures and formulations.

3. Development of lower cost methods starting from the raw grain.

Part 2. Evaluation of a Cereal-based Ration

Shelter habitability test, December 1959

Preliminary evaluation of rations based largely on cereal foods has been made possible through informal cooperation with the U.S. Naval Radiological Defense Laboratory (NRDL). Cereal-based rations have been used in occupancy tests of the NRDL experimental 100-man shelter at Parks Air Force Base in California. Details of the first test, conducted in December 1959, have been reported by Strope (47). Goldbeck and Newman of the American Institute for Research reported on psychological aspects of the test (17).

During the 14-day shelter occupancy in December 1959, three different menus were used:

1. An austere ration of non-fat dried milk reconstituted with water and fortified with dextrimaltose and vegetable oil and supplemented with peanut candy bars.

2. Army C-rations.

3. A cereal-based ration developed by this Laboratory.

The early status of product development precluded use of the wheat wafer described in Part 1 of this chapter. Therefore, products simulating the several menu uses anticipated for the wheat wafer and appropriate food adjuncts to round out the menus were used. The cereal-based ration was served for 3 days out of the 14; complete menus are given in Table 12. Canned boiled wheat (an experimental product of this Laboratory) was used as a breakfast cereal with milk and sugar and as main-course lunch and dinner items with hot sauces or other toppings. Fig newton cookies represented the wafers spread with a fruit topping, and cheese crackers with peanut butter represented the wafers with other flavor adjuncts.

This ration proved quite acceptable and it was easy to prepare and serve. Of the three rations used, it sustained the weight of the occupants best (all diets were planned to provide approximately 2000 cal/day/man) and it produced the fewest subjective complaints, even though it was rated less desirable than the standard Army C-rations. Many individuals on the milk-peanut diet complained of mild diarrhea, whereas those on the C-rations complained frequently of constipation.

TABLE 12

Menus - Parks Air Force Base Shelter Test - December 1959

Breakfast (identical for three days)	
Canned boiled cracked wheat (BCW)	1/2 No. 303 can
Non-fat dried milk	3/10 qt.
Raisins	1-1/2 oz.
Cheese crackers w/peanut butter	4
Sugar	2 tbsp.
Coffee w/dry milk and sugar	1 cup
Noon, day 1	
Canned BCW	1/2 No. 303 can
Dried onion soup	1/5 package
Cheese crackers w/peanut butter	4
Fig newton cookie	1
Coffee w/dry milk and sugar	1 cup
Evening, day 1	
Canned BCW	1/2 No. 303 can
Canned beef gravy	1/5 of 10-1/2 oz. can
Cheese crackers w/peanut butter	4
Candy	1 oz.
Coffee w/dry milk and sugar	1 cup
Noon, day 2	
Canned BCW	1/2 No. 303 can
Dried chicken bouillon	8 grams
Cheese crackers w/peanut butter	4
Fig newton cookie	1
Coffee w/dry milk and sugar	1 cup
Evening, day 2	
Canned BCW	1/2 No. 303 can
Canned chili con carne w/o beans	1/5 of 15-oz. can
Cheese cracker w/peanut butter	4
Candy	1 oz.
Coffee w/dry milk and sugar	1 cup

TABLE 12 (continued)

Noon, day 3	
Canned BCW	1/2 No. 303 can
Canned cheese	3 oz.
Cheese cracker w/peanut butter	4
Fig newton cookie	1
Coffee w/dry milk and sugar	1 cup
Evening, day 3	
Canned BCW	1/2 No. 303 can
Spaghetti sauce w/meat	1/5 of 10-3/4 oz. can
Cheese cracker w/peanut butter	4
Candy	1 oz.
Coffee w/dry milk and sugar	1 cup
	Calories 2189 per day

From questionnaires completed by the occupants (100 adult males), a "discomfort index" relating to many aspects of shelter life was calculated. The wheat ration ranked well down on the list; it was considered less objectionable than lack of water for cleanliness, crowded conditions, lack of seating facilities, noise, the milk-peanut ration, boredom, sleeping conditions, and the ventilation and temperature. Most of the comments on the food in general concerned a desire for more and hotter coffee and some kind of fruit -- fresh, canned, or dried. The adverse comments on the wheat ration were related to expedient substitutes required by the earliness of the test which preceeded most of the developmental work on the wheat wafer. For example, the small cans of boiled wheat were inconvenient to open -- bulk or semi-bulk packaging is envisoned for the wheat wafers; high moisture content of the boiled wheat reduced the effectiveness of the hot topping to heat the serving -- the dry wheat wafers will have low heat capacity and will be well heated by a hot sauce or gravy; and the complaint of "too much wheat, not enough topping" may have been due to the cold wheat problem or to inadequate receipe testing.

Shelter habitability test July 1960

At the time of the second test, development of the wheat wafers had progressed to a point where one-half of the cereal could be presented in the form of wheat wafers. The other half of the cereal

component was in the form of dry, cracked, puffed bulgur kernels, which had been blended with the binding components of the wafers but not pressed into wafer form. (The basic idea for this shelter ration is that pressed wafers could be used either in whole form or crumbled to combine with other foods.) Time and equipment did not allow production of enough wafers for exclusive use.

The wafers were served with a spread of peanut butter or jam, and the coarse meal (as described above) was used with milk and sugar as a breakfast cereal and with hot soup, sauce or other topping for lunch and dinner main course. Table 13 gives the detailed menu for five days. It was necessary to simulate some of the toppings that are envisioned for the cereal-based ration because no product development work on this part of the menu has been authorized.

The concept of a cereal-based ration for shelters has been further strengthened by this test. The ration satisfied hunger and the 100 shelter occupants (adult males) all felt in good health throughout the 5-day test. The chili con carne and spaghetti sauce toppings were the most popular and the beef gravy was liked least. Most occupants ate the cereal promptly before it soaked up the sauces, but if the mixture were allowed to stand a little while it became a fairly soft gruel which small children, the toothless, or the aged could eat. The shelter manager has said that he believes this "hot topping" idea is the best that could be done in the way of serving hot foods in mass shelters and, further, that a completely cold diet would be quite unsatisfactory.

In the questionnaire completed at the end of the shelter stay, nine people out of the 100-man group ranked the food as the worst feature of shelter life, but when asked to suggest diet changes only 4 felt strongly enough about it to suggest specific changes. Of these, 2 wanted more food and 2 wanted more variety.

Specific criticisms of the cereal were concerned with the textural quality of the unpressed cereal. Pressing of the wafers allows a permeation of the binding material into the grain; this improves textural quality and makes the product easier to eat and therefore more acceptable. The wafer form is preferred to the loose cereal, too, because of its greater bulk density which saves storage space, though this may not be a critical factor.

TABLE 13

Menus - Parks Air Force Base Shelter Test - July 1960

Breakfast (every day)

Coffee - 1 cup
Milk - 1 cup (Use approximately 1/4 cup for cereal)
Wheat wafers - 2
Cereals - 1/4 cup
Sugar - 1 tbsp. for cereal plus 1 tsp. for coffee
Raisins - 1-1/4 oz. pkg.
Jam - 1 tbsp.

Morning coffee break (every day)

Coffee - 1 cup
Sugar - 1 tsp.

Lunch (every day)

Milk - 1 cup
Instant cocoa - 1 tbsp.
Wheat wafers - 2
Cereal - 1/4 cup
Peanut butter - 1 tbsp.
Jam - 1 tbsp.

Toppings for cereal:

Day 1 - Chicken bouillon - 1/3 cup
Day 2 - Beef bouillon - 1/3 cup + cheese - 1 tbsp.
Day 3 - Beef bouillon with chili seasoning - 1/3 cup
Day 4 - Onion soup - 1/3 cup
Day 5 - Beef bouillon with curry powder - 1/3 cup

Afternoon coffee break (every day)

Coffee - 1 cup
Sugar - 1 tsp.

TABLE 13- Menus - Parks Air Force Base Shelter Test - July 1960 (cont.)

Supper (every day)

Milk - 1 cup
Wheat wafers- 2
Cereal - 1/4 cup
Candy - 1 oz. pkg.
Peanut butter - 1 tbsp.
Jam - 1 tbsp.

Toppings for cereal:

Day 1 - Beef Gravy - 1/3 cup
Day 2 - Tomato-vegetable soup - 1/3 cup
Day 3 - Mushroom soup - 1/3 cup
Day 4 - Spaghetti sauce - 1/3 cup
Day 5 - Chili con carne - 1/3 cup

Total calories - 2035/day   Protein, 57 g./day

There were certain inconveniences connected with the mixing and handling of the toppings. These could be largely overcome if it were possible to work out improved products and packages. Individual toppings could be packaged as units of a size suitable for preparation of one meal for any predetermined number of occupants. An extremely simple system for the toppings could consist of blending a topping from a stock of dehydrated chicken or beef bouillon and several flavoring adjuncts such as chili powder, dehydrated spaghetti sauce, dried onions, mushrooms and other vegetables. Many combinations would be possible.

The general acceptability by this group of healthy adult males of the cereal-based ration using compressed wheat wafers has been established. Nothing encountered in the test leads to cost expectations different from those indicated in Chapter 6 for the cereal-based ration.

Shelter habitability test, November 1960

Another shelter test has been conducted, but data from it have not yet been fully evaluated. Inasmuch as the population in this test differed greatly from those in the earlier tests, preliminary observations are worth noting here. The earlier tests

had involved only men, chiefly volunteers from NRDL and prisoners from a minimum security prison camp. In the present test, a group of 99 men, women, and children occupied the shelter at Parks Air Force Base for 48 hours. There were 51 adults (21 to 68 years), 19 teenagers, and 29 children (2 months to 12 years).

Food was served three times each day and there were two "coffee breaks" per day. The complete menu appears in Table 14. The wheat wafers were prepared as described in Part 1 of this chapter; other components of the menu were commercial items.

Not unexpectedly, the acceptance of this diet was not as general by the mixed population as it had been by the population of relatively young, healthy men. The children, particularly, varied greatly in their attitudes toward the food. Some refused the wheat wafers entirely--they ate only jam, peanut butter, and candy. Some refused the first two meals, but ate very well after they had become hungry. Others ate well throughout the test. This last group included children down to age 17 months. In general, the small children preferred the dry wafers with jam and peanut butter to the cereal-sauce mixtures.

The adults, understanding the nature of the test and the reasons for the choice of foods, all ate adequately. However, 2000 calories-worth of food (at least in this form) may be much more than necessary for a group of this kind. Approximately 1/3 of the wheat wafers were not eaten. Had the test run longer, perhaps appetities would have increased--or boredom with the fare might have produced the opposite effect. Teenagers ate very well, but from this group came both the loudest complaints and the most enthusiastic endorsements.

An informal survey revealed a general desire for more "topping" for the pilaf-type mixture. Perhaps a soup would be more acceptable, with the cereal used in much the fashion that barley and rice are frequently used in soup. This approach introduces two problems: part of any rationed water supply would have to be used in the food rather than as a beverage, and the hazard created by distributing hot soup in a crowded shelter might be quite great.

The last meal served in the shelter included a topping for the cereal that was very salty. It consisted of bouillon with added chili seasoning (which includes salt) and a generous sprinkling of Parmesan cheese. This mixture was received with surprising enthusiasm. Perhaps the salt level in the diet had been too low.

TABLE 14

Menus - Parks Air Force Base Shelter Test - November 1960

Breakfast (each day)

Coffee - 1 cup
Milk - 1 cup (use approx. 1/4 cup for cereal)
Wheat wafers - 4
Sugar - 1 tbs. for cereal + 1 tsp. for coffee
Raisins - 1-1/4 oz. package
Jam - 1 tbs.

Morning coffee break (each day)

Coffee - 1 cup
Sugar - 1 tsp.
Fruit-flavored beverage for children

Lunch (each day)

Milk - 1 cup
Instant cocoa - 1 tbs.
Wheat wafers - 4
Peanut butter - 1 tbs.
Jam - 1 tbs.

Toppings for cereal wafers (use 2 wafers crumbled)

Day 1 - Beef bouillon - 1/3 cup + cheese - 1 tbs.
Day 2 - Beef bouillon with chili seasoning - 1/3 cup.

Afternoon coffee break (each day)

Coffee - 1 cup
Sugar - 1 tsp.
Fruit-flavored beverage for children

Supper (each day)

Milk - 1 cup
Wheat wafers - 4
Peanut butter - 1 tbs.
Jam - 1 tbs.
Hard candy - 1 oz.

Toppings for cereal wafers (use 2 wafers crumbled)

Day 1 - Tomato-vegetable soup - 1/3 cup
Day 2 - Spaghetti sauce - 1/3 cup

Calories - 2000 per day

This shelter test was particularly useful in pointing up some of the problems associated with food preparation and serving. The following list of precautions and suggestions may be applicable to shelters in general as well as to this shelter specifically.

1. Vessels for heating, carrying, and serving liquids should have handles and pouring spouts or lips.

2. Provide gloves or holders for handling hot pans.

3. Have the kitchen work surface low enough to be convenient for women of average height.

4. The food preparation area should have some barrier arrangement to keep the crowd from pressing in on the food handlers. The danger of scalding a child is quite great. Perhaps a serving counter could be fastened flush with the wall and let down to give extra work area during meal preparation and serving.

5. All equipment and work surfaces should be of a form and material that are very easy to clean.

6. Food storage and water source should be easily accessible to food preparation area.

<u>Suggested Areas for Research</u>

1. Development of an adequate line of stable food adjuncts to increase the menu possibilities of cereal wafers for emergency feeding in fallout shelters.

2. Improvement in processes and packaging for cereal wafers and adjuncts to reduce cost of production, to increase ease of food service, and to enhance stability of products.

3. Investigation of the use of cereals other than wheat for a wafer with characteristics suitable for shelter stockpiling.

4. Improvement in the formulation and production of cereal wafers to control textural quality in relation to texture preference in wafers when they are used either as a cracker or as a base for a pilaf-type hot dish.

5. Investigation of the nutritional and salt balance appropriate to a shelter diet.

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